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# Manufacturing Sector



May 2025



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# Thailand Taxonomy Board

#### Manufacturing sector

- 1. Department of Climate Change and Environment, Ministry of Natural Resources and Environment
- 2. Bank of Thailand
- 3. Securities and Exchange Commission
- 4. Stock Exchange of Thailand
- 5. Department of Alternative Energy Development and Efficiency, Ministry of Energy
- 6. Thailand Greenhouse Gas Management Organization
- 7. Office of Natural Resources and Environmental Policy and Planning, Ministry of Natural Resources and Environment
- 8. Department of Industrial Works, Ministry of Industry
- 9. Thai Industrial Standards Institute, Ministry of Industry
- 10. Industrial Estate Authority of Thailand
- 11. Board of Trade of Thailand
- 12. Federation of Thai Industries
- 13. Renewable Energy Industry Club, Federation of Thai Industries
- 14. Thai ESCO Association
- 15. Thai Bankers' Association
- 16. Association of International Bank
- 17. Government Financial Institutions Association



#### 1. Manufacturing sector background

The manufacturing sector contributes 27% to Thailand's GDP in 2022, rising from 13% in 1960.<sup>1</sup> The sector will account for 73% of Thailand's total exports in 2022 and employ almost 5.84 million workers in 2021, or roughly 15% of the total labour force.<sup>2</sup> Office of Industrial Economics identifies and tracks the performance of Thailand's economically important manufacturing industries, given their shares in the country's production, domestic consumption, and exports and imports. As for the most climate-material manufacturing subsectors, their economic status is as follows:

- Petrochemicals: Thailand's petrochemical industry is the largest in ASEAN with a total production capacity in 2021 of 35 million tons, comprising 13.4 million tons of upstream products, 8.5 million tons of intermediate goods and 13.3 million tons of downstream outputs. <sup>3</sup> Over 80% of Thai upstream and intermediate production is for domestic use as inputs for further downstream processes.<sup>4</sup> Naphtha is the main feedstock (68% of total feedstock consumption). Ethylene is the world's most widely produced olefin and accounts for 41% of Thailand's total upstream production, with the country's capacity to produce ethylene being ranked 9th in the world.<sup>5</sup>
- Cement: Thailand is among the largest producers of cement in Asia. Cement production (excluding clinker) in Q1/2023 reached 10.92 million tons, representing a quarter-on-quarter (QoQ) increase of 8.05 % from Q4/2022 but a year-on-year (YoY) decrease of 3.49% from the same quarter in 2022.<sup>6</sup> Approximately 91% of cement produced is for the domestic market, with 9% of production exported. Around 60%

- <sup>2</sup> National Statistical Office, "The Labor Force Survey Whole Kingdom Quarter 4: October-December 2021," Ministry of Digital Economy and Society of Thailand, https://webapps.ilo.org/surveyLib/index.php/catalog/8045/related-materials
- <sup>3</sup> Thian Thiumsak, "Industry Outlook 2023-2025: Petrochemicals," krungsri research, n.d.,

<sup>&</sup>lt;sup>1</sup> World Bank, "World Bank Open Data," World Bank Open Data, n.d.,

https://data.worldbank.org/indicator/NV.IND.MANF.ZS?locations=TH.

https://www.krungsri.com/en/research/industry/industry-outlook/petrochemicals/petrochemicals/io/io-petrochemicals-2023-2025.

<sup>&</sup>lt;sup>4</sup> Ibid.

<sup>&</sup>lt;sup>5</sup> Ibid.

<sup>&</sup>lt;sup>6</sup> Office of Industrial Economics, "Report on the Industrial Economics Status in Q1-2023 and Outlook for Q2- 2023,"n.d., https://www.oie.go.th/assets/portals/1/files/quarterly\_industrial/Q1\_2023andOutlookQ2\_2023\_en.pdf.

of the output is used in private sector construction (mostly in residential and commercial properties), and the remaining 40% in public sector projects.<sup>7</sup>

- Basic iron and steel: Thailand produces more long steel products than flat ones. As of November 2023, Thailand's production of finished steel products stood at 472,545 tons, contracting 20.5% (YoY) from 2022.<sup>8</sup> Thai steel products are consumed more domestically than exported, roughly at a 91:9 ratio. Long products (deformed bar and structural steel) are mainly used in the construction business, while flat products tend to be used in sectors such as automobiles and electrical appliances.<sup>9</sup>
- Aluminium: As of 2022, Thailand had a total production capacity of over 710,000 tons but actually produced only 571,000 tons, or 80% of the production capacity, with a total market value of approximately 80 billion baht.<sup>10</sup> Thai aluminium producers can be divided into two categories: flat roll, with a combined production capacity of up to 410,000 tons, and extrusion, with a production capacity of up to 300,000 tons. Thailand ranks second in the world in terms of the complete closed-loop recycling of aluminium cans at 91%.<sup>11</sup>
- Plastic products: Thailand is the world's 11th biggest exporter of plastics and the 2nd biggest in the ASEAN.<sup>12</sup> The Thai plastics industry benefits from the large and competitive domestic petrochemicals sector. Around 59% of the produced output is exported, and the remaining 41% is used to manufacturing products for domestic industries, most notably in auto assembly, electronics and electrical appliances and

https://www.krungsri.com/en/research/industry/industry-outlook/construction-construction-materials/steel/io/io-steel-20. <sup>10</sup> ฐานเศรษฐกิจ and ฐานเศรษฐกิจ, "จีนทุ่มตลาดหนัก อะลูมิเนียมไทยป่วน! จี้เร่งใช้เอดีปกป้อง," Thansettakij, March 9, 2023,

https://www.thansettakij.com/columnist/exclusive-area/558442.

<sup>&</sup>lt;sup>7</sup>Puttachard Lunkam, "Industry Outlook 2023-2025: Construction Materials," krungsri Research, n.d.,

https://www.krungsri.com/en/research/industry/industry-outlook/construction-construction-materials/construction-materials/construction-materials/2023-2025.

<sup>&</sup>lt;sup>8</sup> IRON & STEEL INTELLIGENCE UNIT and IRON AND STEEL INSTITUTE OF THAILAND, "THAILAND STEEL INDUSTRY REPORT – September 2023 - OIE," report, September 2023, https://km.fti.or.th/wp-content/uploads/2023/10/4.ภาวะอุตสาหกรรมเหล็ก และเหล็กกล้า-โดยสถาบันเหล็กและเหล็กกล้าแห่งประเทศไทย-28-ก.ย.66.pdf.

<sup>&</sup>lt;sup>9</sup> Taned-Mahattanalai, "Industry Outlook 2019-2021: Steel Industry," Krungsri Research, n.d.,

<sup>&</sup>lt;sup>11</sup>Reedtradex, "Thai Aluminium to Reach Global Market and Save the Planet / เตรียมพร้อมอลูมิเนียมไทย ก้าวไกลและรักษ์โลก," n.d., https://www.reedtradex.co.th/enews/mtx23enews12/index\_en.html.

<sup>&</sup>lt;sup>12</sup> Aphinya Khanunthong, "Industry Outlook 2021-2023: Plastics," krungsri.com, n.d.,

https://www.krungsri.com/en/research/industry/industry-outlook/petrochemicals/plastics/io/io-plastics-21.

construction.<sup>13</sup> Polypropylene (PP), Polyethylene Terephthalate (PET), Low-Density Polyethylene (LDPE)/ Linear Low-Density Polyethylene (LLDPE) and High-Density Polyethylene (HDPE) represent 78% of all resins consumed in Thailand, with around 18% of key resins being recycled as of 2018.<sup>14</sup>

The primary plastics production industry in Thailand is witnessing significant growth, driven by robust demand across various sectors such as packaging, automotive, and construction. As of 2024, the market size is expected to grow by approximately USD 10.75 billion from 2023 to 2028, reflecting a compound annual growth rate of 5.18%<sup>15</sup>. Key factors contributing to this growth include advancements in plastic manufacturing technologies, increased investments, and a rising demand for lightweight, durable materials. The packaging sector remains the largest segment, fueled by the booming e-commerce market and the need for sustainable packaging solutions. Key factors contributing to this growth include advancements in plastic manufacturing technologies, increased investments, and a rising demand for lightweight, durable materials. The packaging sector remains the largest segment, fueled by the booming e-commerce market and the need for sustainable packaging solutions. Key factors contributing to this growth include advancements in plastic manufacturing technologies, increased investments, and a rising demand for lightweight, durable materials. The packaging sector remains the largest segment, fueled by the booming e-commerce market and the need for sustainable packaging solutions.

• Automotives: Thailand is the largest automotive producer in Southeast Asia and is ranked 10<sup>th</sup> globally as a production base.<sup>17</sup> The Thai automotive industry is structured in a pyramid, with car makers on top and auto parts makers in lower layers. As of 2022, there were 27 motor vehicle makers and 18 motorcycle makers. <sup>18</sup> In 2022, Thailand's car production totalled 1.88 million cars, of which 44.7% (around 0.84 million cars) were assembled for the domestic market and the remaining portion (around 1 million cars) for export. Pickups represented 62% of total car production in

<sup>&</sup>lt;sup>13</sup> Ibid.

<sup>&</sup>lt;sup>14</sup> Open Knowledge Repository, "Market-Study-for-Thailand-Plastics-Circularity-Opportunities-and-Barriers," n.d., https://openknowledge.worldbank.org/bitstreams/76c48f2a-d0c2-5a70-b801-43e37d851fc1/download.

<sup>&</sup>lt;sup>15</sup> Mordor Intelligence, "Thailand Plastic Market Size & Share Analysis - Growth Trends & Forecasts (2024 - 2029)", n.d.,

https://www.mordorintelligence.com/industry-reports/thailand-plastics-market

<sup>&</sup>lt;sup>16</sup> Industry Team, Bank of Ayudhya Public Company Limited, "Thailand Industry Outlook 2024-2026", January 10, 2024, https://www.krungsri.com/en/research/industry/summary-outlook/industry-outlook-2024-2026

<sup>&</sup>lt;sup>17</sup> Thailand Board of Investment, "Thailand Automotive Industry, situation from ICE to Next-generation vehicle," July 6, 2023, https://www.boi.go.th/upload/content/20230706%20EN%20TAI .pdf.

<sup>&</sup>lt;sup>18</sup> Thai Automotive Industry, "Thai Automotive Industry - Facts and Figures," 2022,

https://data.thaiauto.or.th/images/PDF/Navigator/Thai\_Automotive\_Industry-Facts\_and\_Figures\_2022.pdf.

Thailand, while passenger cars accounted for a 35% share and other commercial vehicles (trucks, vans, and buses) for the remaining share. Battery electric vehicles remain the newcomer in Thailand's motor vehicle market, which is currently dominated by internal combustion engine vehicles.<sup>19</sup>

• Electrical appliance Industry: Thailand is a major producer and exporter of electrical appliances such as refrigerators, microwave ovens, thermos pots, household fans, washing machines, air-conditioners, compressors, rice cookers etc. In Q1/2023, exports of electrical appliances were valued at USD 8.2 billion, an increase of 18.5% (QoQ) compared to the previous quarter and an increase of 8.1% (YoY) from the same quarter last year. Products that experienced an increase in exports were air conditioners (43.1%), refrigerators (27.3%), and washing machines (26.4%).<sup>20</sup> The production index of the electrical appliance industry is expected to expand by approximately 4.0%.<sup>21</sup>

While being a main driver of the Thai economy, the manufacturing sector has recently experienced weakening conditions due to declining exports. In 2023, the manufacturing industries, particularly those associated with exports, contracted by 3 % (YoY) on average for the first three quarters of the year.<sup>22</sup> Exceptions were the automotive and petroleum refining sectors, which expanded in 2023.<sup>23</sup> From the investment perspective, manufacturing is driving foreign direct investment (FDI) flows into Thailand.

FDI in 2022 proved largest in metal products and machinery, followed by electrical and electronic products as well as services, with recent investment applications approved by the Board of Investment of Thailand in 2023 shifting towards electrical appliances and electronics

<sup>21</sup> Ibid.

<sup>&</sup>lt;sup>19</sup> Ibid.

<sup>&</sup>lt;sup>20</sup> Office of Industrial Economics, "Report on the Industrial Economics Status in Q1-2023 and Outlook for Q2- 2023,"n.d., https://www.oie.go.th/assets/portals/1/files/quarterly industrial/Q1 2023andOutlookQ2 2023 en.pdf.

<sup>&</sup>lt;sup>22</sup> World Bank, "Thailand Economic Monitor - Thailand's Path to Carbon Neutrality: The Role of Carbon Pricing," World Bank, Bangkok December 2023,

https://documents1.worldbank.org/curated/en/099121223123018912/pdf/P5010091ef52cc09d1b46c1af1a43820def.pdf

<sup>&</sup>lt;sup>23</sup> The office of Industrial Economics, "Montly Report Industrial Index April 2023 - April 2024," n.d., https://www.oie.go.th/view/1/industrial indices/EN-US.

as well as electric vehicles.<sup>24</sup> Investments in the manufacture of EV batteries are also rising in Thailand, due partly to the "30@30" policy --which sets the goal for 30% of vehicles made in Thailand to be zero-emission vehicles (ZEV) by 2030<sup>25</sup>, and to related government support measures aimed at enabling Thailand to become a hub of electric vehicles manufacturing in ASEAN. Ahead of the 2030 target, ZEV production is expected to reach 225,000 units/year in 2025.<sup>26</sup>

#### 1.1 Major climate and environment-related issues

Climate change presents key transition and physical risks for Thailand's manufacturing industries, calling for the adoption of climate change mitigation and adaptation strategies across sub-sectors.

As a major contributor to Thailand's GHG emissions, Thailand's manufacturing sector is developing strategies to accelerate decarbonisation. The sector currently produces a large amount of GHG emissions from chemical and physical processes, accounting for 37% of the country's final energy consumption. Cement production is Thailand's second highest emitting individual activity after rice cultivation. While traditionally focused on growth and production efficiency, Thai manufacturers are increasingly recognising the urgent need for sustainable practices. Many are adopting cleaner technologies, implementing energy-efficient processes, and optimising resource usage to minimise their carbon footprint.

Recognising the need to accelerate mitigation actions, the Ministry of Industry (MIND) implements the Bio, Circular and Green economic model to drive economy-wide decarbonisation and sustainable growth of Thai manufacturing industries.<sup>27</sup> External factors also act as an additional driver for the low-carbon transition of the manufacturing sectors. For

<sup>&</sup>lt;sup>24</sup> World Bank, "Thailand Economic Monitor - Thailand's Path to Carbon Neutrality: The Role of Carbon Pricing," World Bank, Bangkok December 2023,

https://documents1.worldbank.org/curated/en/099121223123018912/pdf/P5010091ef52cc09d1b46c1af1a43820def.pdf <sup>25</sup> TDRI, "Clean Energy Needs Far Clearer Policy," TDRI: Thailand Development Research Institute, September 2, 2022, https://tdri.or.th/en/2022/08/clean-energy-needs-far-clearer-policy/.

<sup>&</sup>lt;sup>26</sup> S&P Global, "Thailand braces to make a big splash in EV sector," Nov 8 ,2023,

https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/metals/110823-thailand-braces-to-make-a-big-splash-in-ev-sector

<sup>&</sup>lt;sup>27</sup>United Nations Framework Convention on Climate Change, "Thailand LT-LEDS (Revised Version)," November 8, 2022, https://unfccc.int/sites/default/files/resource/Thailand%20LT-LEDS%20%28Revised%20Version%29\_08Nov2022.pdf

example, the introduction of the Carbon Border Adjustment Mechanism (CBAM) by the European Union in October 2023 is expected to accelerate mitigation actions in aluminium and steel, which are the two current Thai CBAM goods, and potentially in more sectors in the future.<sup>28</sup> Moreover, partnerships with governmental bodies and international organisations are fostering the development of eco-friendly regulations and incentives. However, challenges persist, including ensuring the inclusivity of small and medium-sized enterprises in decarbonisation and sustainability efforts.

Apart from contributing to climate change, manufacturing industries suffered tremendous damage from the severe floods in 2011, which hit seven industrial parks in the northern suburbs of Bangkok, affecting 730 companies and disrupting global supply chains of electronic components, disk drives and auto parts.<sup>29</sup> Physical risks from climate change can also affect the manufacturing sector through other channels, such as changes in the quantity and quality of water supply and higher frequency of extreme heat events affecting workers' welfare. More investment in adaptation and resilience measures is needed to reduce the vulnerability of the manufacturing sector to physical risks from climate change.

Waste is another important problem associated with the manufacturing sector (for more on that please read Waste Sector information). During the coronavirus epidemic, industrial waste volumes fell sharply due to quarantines at factories, falling demand and supply chain disruptions, but have since recovered and even increased. For example, it was 18.05 million tonnes in 2020 but rose to 35.55 million tonnes by 2022. However, the government's efforts to reduce the total volume of industrial waste are yielding results compared to 2015, when

<sup>&</sup>lt;sup>28</sup> In the short term, the effects of the CBAM on the Thai industry are expected to be slight. Among the CBAM goods, the most important ones for Thailand are iron and steel (around 1.5% of exports to the EU) and aluminium (around 0.4% of exports), while the sales of other CBAM goods to the EU are either very low or non-existent. However, the list of CBAM goods will gradually expand to match those covered under the EU ETS, while other countries (such as the US and Canada, etc.) are also considering measures similar to CBAM. This will likely significantly amplify the impacts of carbon border adjustments on Thai manufacturers and exporters across more sectors in the long run. For more information see: Prapan Leenoi, "Countdown to the CBAM: How prepared is Thailand for the introduction of the EU carbon tax?," krungsri Research, August 03, 2023, https://www.krungsri.com/en/research/research-intelligence/cbam-2023.

<sup>&</sup>lt;sup>29</sup> Nikkei Editorial, "Global Companies Must Learn From Thai Floods That Upended Supply Chains," Nikkei Asia, October 13, 2021, https://asia.nikkei.com/Opinion/The-Nikkei-View/Global-companies-must-learn-from-Thai-floods-that-upended-supply-chains.

the volume of waste was 37.4 million tonnes<sup>30</sup>. Industrial waste management, key challenges remain in enhancing the monitoring of the renewal of factories that lack industrial waste management, mandating them to carry out industrial waste management systematically and legally, and enforcing the law on industrial factories that have not been legally entered into the industrial waste management system<sup>31</sup>.

Another problem is the country's production and consumption of plastics, a large portion of which, due to mismanagement, often end up in the oceans. Approximately 51,000 tons of uncollected and improperly disposed plastic waste in Thailand gets washed into the sea each year, and the country is ranked sixth in the world on this indicator<sup>32</sup>. According to a World Bank study, despite a high municipal solid waste collection and recycling rate of 88.8% in Thailand, remaining uncollected plastic waste and many unsanitary disposal facilities result in an estimated 428 ton/year of mismanaged plastic waste<sup>33</sup>. Only about 25% of the country's plastic waste is recycled. For used plastic bags, while the beverage boxes still have no proper systems for collection and value-adding.<sup>34</sup> To address this problem more systematically, Thailand is in the process of drafting the Extended Producer Responsibility (EPR) Law, which promotes the sustainable management of plastic waste with the participation of the plastic manufacturing industry<sup>35</sup>.

<sup>&</sup>lt;sup>30</sup> Office of Natural Resources and Environmental Policy and Planning"ปริมาณกากของเสียอุตสาหกรรม (อันตรายและไม่อันตราย) (2558-2565),"n.d., http://env\_data.onep.go.th/reports/subject/view/153

<sup>&</sup>lt;sup>31</sup> Pollution Control Department, "Thailand State of Pollution Report," 2022, https://www.pcd.go.th/wp-

content/uploads/2022/08/pcdnew-2022-08-08\_08-30-05\_795080.pdf.

<sup>&</sup>lt;sup>32</sup> United Nations Environment Programme, "Circular solutions for plastic pollution,"n.d.,

https://wedocs.unep.org/bitstream/handle/20.500.11822/41861/behavior\_change.pdf?sequence=3&isAllowed=y.

<sup>&</sup>lt;sup>33</sup>World Bank, "Plastic Waste Material Flow Analysis for Thailand- Summary Report," 2022,

https://documents1.worldbank.org/curated/en/099515103152238081/pdf/P17099409744b50fc09e7208a58cb52ae8a.pdf.

<sup>&</sup>lt;sup>34</sup> Nationthailand, "Packaging Producers Push for Enactment of EPR Law," Nationthailand, August 11, 2023,

https://www.nationthailand.com/thailand/general/40030126.

<sup>&</sup>lt;sup>35</sup> Ibid.

#### 1.2 Key sectoral climate policies

The Department of Industrial Works (DIW), Ministry of Industry (MINDI) has prepared **the NDC Sectoral Action Plan for the IPPU Sector (2021 – 2030)** to reduce GHG emissions in the manufacturing sector by setting targets for implementation in two phases:

- The preparation phase (2019 2020) supports the implementation of measures according to the NDC roadmap starting in 2021;
- The action phase (2021 2030) has targets for driving key measures and supporting measures to reduce GHG emissions in the manufacturing sector to achieve the goal within the year 2030, according to the NDC Roadmap and Action Plan.

As major GHG emissions from the manufacturing sector are from the cement, chemical, refrigeration, and air conditioning industries, respectively, key mitigation measures in the sector focus mainly on clinker substitution and substitution of high global warming potential (GWP) refrigerants.<sup>36</sup> Specifically, the NDC Sectoral Action Plan for IPPU includes two main mitigation measures:

- Clinker substitution measures with two sub-activities: the use of clinker substitutes in the hydraulic cement production process and the increased use of cement substitutes in ready-mixed concrete.
- **Refrigerant replacement measures** with two sub-activities: refrigerant modification under the Thailand Refrigeration and Air Condition Nationally Appropriate Mitigation Actions (RAC NAMA) project<sup>37</sup> and the proper disposal of waste and deteriorated refrigerant.

By 2040, it is also expected that carbon capture utilisation and storage (CCS/ CCUS) technologies will contribute substantially to further carbon removal from the cement industry.

<sup>37</sup> Thailand RAC NAMA, "Thailand Refrigeration and Air Conditioning Nationally Appropriate Mitigation Action (RAC NAMA)," n.d., https://www.egat.co.th/home/wp-content/uploads/2023/11/4.-Factsheet-RACNAMA EN.pdf.

<sup>&</sup>lt;sup>36</sup> United Nations Framework Convention on Climate Change, "Thailand LT-LEDS (Revised Version)," November 8, 2022, https://unfccc.int/sites/default/files/resource/Thailand%20LT-LEDS%20%28Revised%20Version%29\_08Nov2022.pdf.



#### Figure 1 Manufacturing sector decarbonisation timeline

Source: ONEP (2022). Thailand's Long-Term Low Greenhouse Gas Emission Development Strategy (Revised Version November 2022)

Energy efficiency, fuel-switching, and electrification of end-use technologies are also key to the decarbonisation of manufacturing industries. According to LT-LEDS, the electrification of end-use technologies in the industrial sector includes replacing non-electricity-based technologies with electricity-based ones. The potential to replace fossil fuels partially or completely with renewables, such as biomass and solar, in heating applications also exists in the manufacturing industries. Green hydrogen produced using renewable-based electricity will also play an important role in the decarbonisation of hard-to-abate sectors that cannot be electrified easily, such as basic iron and steel, aluminium, and cement. Hydrogen burners could be used in conjunction with electric heating to generate the high temperatures required in many heavy industrial processes and replace fossil fuel burning.<sup>38</sup>

Apart from national climate policy goals in the IPPU sector, several industry-level climate actions have also been implemented to accelerate decarbonisation in various manufacturing sectors in Thailand. For example:

• Thai cement manufacturers have begun to invest in green technology, including in the production of hydraulic cement, to help cut CO<sub>2</sub> emissions. The Thai Cement Manufacturers Association (TCMA) has set the "Mission 2023" for cutting GHG emissions by at least 1 million tons of CO<sub>2</sub> by 2023 by encouraging all sectors to use hydraulic

<sup>&</sup>lt;sup>38</sup> United Nations Framework Convention on Climate Change, "Thailand LT-LEDS (Revised Version)," November 8, 2022, https://unfccc.int/sites/default/files/resource/Thailand%20LT-LEDS%20%28Revised%20Version%29\_08Nov2022.pdf.

cement in all types of construction projects.<sup>39</sup> The Thai cement industry has also pledged to reach net zero emissions by 2050. The TCMA has published the Thailand Net Zero Cement & Concrete Roadmap 2050, which seeks to halve GHG emissions by 2030 and ultimately achieve net zero by 2050.<sup>40</sup>

- An MOU was signed between the Aluminium Industry Club of the Federation of Thai Industries (FTI), the National Metal and Materials Technology Center, and 11 aluminium producers to mutually determine the median GHG emission value to serve as a baseline for decarbonisation. In addition, the industry is increasingly using solar-powered electricity generation and recycled aluminium scraps as raw materials.<sup>41</sup>
- The National Electric Vehicle Policy Committee sets the vision for Thailand to be one of the most important EV production bases and component parts in 2035. Current EV promotion measures include supply-side measures (e.g., EV and charger standards, testing facility <sup>42</sup>, supply chain transition program, End-of-Life Vehicle program, investment promotion scheme) and demand-side measures to incentivise EV purchases (e.g., customs tax, excise tax, subsidy, and annual road tax) and infrastructure development.<sup>43</sup>
- The bioplastics industry in Thailand is expanding rapidly, driven by both domestic and international demand for sustainable materials. As the country strives to reduce its environmental footprint, the production and use of bioplastics have been prioritized. In 2023, Thailand was one of the largest producers of bioplastics in the ASEAN region, with a production capacity of approximately 95,000 tons per year. The industry is expected to grow at a rate of around 20% through 2025, reflecting increasing

https://www.prachachat.net/economy/news-865746.

<sup>&</sup>lt;sup>39</sup>Asia Cement, "TCMA Together With 25 Alliances Announced 'Mission 2023' on Greenhouse Gas Mitigation," Asia Cement, March 31, 2022, https://www.asiacement.co.th/en/tcma-together-with-25-alliances-announced-mission-2023-on-greenhousegas-mitigation#:~:text=We%20therefore%20announced%20%22MISSION%202023,gas%20emission.%22%20stated%20Mr.

 <sup>&</sup>lt;sup>40</sup> TCMA, "Thailand 2050 Net Zero Cement & Concrete Roadmap," n.d., https://www.thaicma.or.th/th/ebook\_detail/3/197.
 <sup>41</sup> Prachachat.net, "ส่องอุตาอะลูมิเนียมปี'65 ต้นทุนสิ่งแวดล้อมดันราคาขายพุ่ง," Prachachat.Net, February 18, 2022,

<sup>&</sup>lt;sup>42</sup> The Automotive and Tyre Testing, Research and Innovation Center (ATTRIC)

<sup>&</sup>lt;sup>43</sup> Clement Choo and Leah Chen, "Thailand braces to make a big splash in EV sector," S&P Global, November 8, 2023,

https://www.spglobal.com/commodityinsights/en/market-insights/latest-news/metals/110823-thailand-braces-to-make-a-big-splash-in-ev-sector.

investments and favorable government policies<sup>44</sup>. Economic incentives from the Thai government, such as tax benefits and subsidies, are bolstering the bioplastics sector. These measures aim to promote the use of renewable resources, which in Thailand include locally available agricultural products like cassava, sugarcane, and corn.

The government has introduced initiatives like the "Thailand 4.0" model, which supports the development of bioplastics as part of the country's shift towards an innovation-driven economy. Challenges remain, however, including higher production costs compared to conventional plastics and the need for greater consumer awareness and infrastructure to handle bioplastic waste effectively.

#### 2. Manufacturing activities climate materiality

Manufacturing activities in GHG inventories are covered by the Industrial Process and Product Use (IPPU) category under Thailand's GHG inventory. It is important to note that this category only accounts for the emissions accompanying the chemical processes of manufacture and does not cover the emissions accompanying the generation of electricity for the production processes (except for the captive power plants situated within the factory)<sup>45</sup>. The national GHG inventory data will be used to assess the mitigation potential of the inclusion of activities in the Taxonomy. The table below includes only activities that contribute more than 1% to the overall IPPU sector emission volume and compares them to the proposed activities to be covered under the manufacturing sector under this Taxonomy.

Subsector	IPCC 2006	Manufacturing sector GHG	Corresponding proposed activities
	Code	emission, total in GgCO <sub>2</sub> eq	under the Thailand Taxonomy
		(share of total sectoral	
		emission, %)	
Cement	2A1	15,803.16 (38.99%)	Manufacture of cement
Production			
Chemical Industry	2B	11,668.31 (28.79%)	Manufacture of hydrogen

Table 1	Industrial	Process and	Product Use	e sector	emission	profile
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<sup>&</sup>lt;sup>44</sup> Mordor Intelligence, "Thailand Plastic Market Size & Share Analysis - Growth Trends & Forecasts (2024 - 2029)", n.d., https://www.mordorintelligence.com/industry-reports/thailand-plastics-market

<sup>&</sup>lt;sup>45</sup> Please note that IPCC methodology that serves as a basis for creating GHG inventories is not . The Taxonomy itself mostly requires measurement of Scope 1+2 emissions (see particular activity cards and Business Guide for clarifications).

Subsector	IPCC 2006	Manufacturing sector GHG	Corresponding proposed activities
	Code	emission, total in GgCO <sub>2</sub> eq	under the Thailand Taxonomy
		(share of total sectoral	
		emission, %)	
			Manufacture of carbon black
			Manufacture of soda ash
			Manufacture of chlorine
			Manufacture of ethylene, propylene,
			butadiene
			Manufacture of aromatics
			(acetylene, benzene, xylene, and
			toluene)
			Manufacture of anhydrous ammonia
			Manufacture of nitric acid
			Manufacture of plastics in primary
			form
Basic iron and	2C1	425.32 (1.05%)	Manufacture of basic iron and steel
Steel Production			
Refrigeration and	2F1	10,383.15 (25.62%)	Covered in the Energy sector of
Air conditioning			Phase I (4.1.9; 4.1.10; 4.1.11)
Electrical	2G1	756.09 (1,86%)	Covered by five activity cards in
Equipment			the Enabling activities as well as
			by the auxiliary transitional
			activity

Source: Thailand's First Blennial Transparency Report <sup>46</sup>

The largest proportion of emissions from the manufacturing sector for Thailand is the production of cement and chemicals, both of which have been proposed to be included in the Taxonomy. In addition, almost all international taxonomies include activities such as the production of aluminium, basic iron, and steel because these activities consume a lot of electricity and have significant associated emissions.

<sup>&</sup>lt;sup>46</sup> "Thailand's First Biennial Transparency Report under the United Nations Framework Convention on Climate Change." UNFCCC. Published December 26, 2024. https://unfccc.int/documents/645098

Furthermore, manufacture of hydrogen involves the production of low-carbon hydrogen, which can subsequently be used for energy production, in transport or in industry.

In addition to activities directly aimed at reducing production-related emissions in the climatematerial manufacturing activities above, it is also proposed to include a number of enabling manufacturing activities in the Taxonomy:

- 1. **Manufacture of batteries**. This activity includes the production of batteries capable of storing electricity and thereby increasing the potential use of renewable energy sources as opposed to non-renewable ones.
- 2. Manufacture of renewable energy technologies and products. This activity includes the production of technologies and components necessary for the operations of renewable facilities and the production of low-carbon energy as defined by the Taxonomy, such as solar panels, blades of wind generators, turbines for hydroelectric power plants, etc.
- 3. Manufacture of low-carbon technologies for transport. This activity includes the assembly and production of components for vehicles that meet the criteria of this taxonomy (zero tailpipe emissions).
- 4. **Manufacture of energy efficiency equipment for buildings**. This activity includes the production of various components and machines that help reduce the emission of buildings and their consumption of basic resources (water or energy).
- 5. Manufacture of other low-carbon technologies. This activity includes the manufacture of electronics and household appliances that meet the highest performance level of the energy rating system introduced by the National Energy Authority, as well as machinery needed to decarbonise other sectors of the economy.
- 6. **Carbon capture-related activities.** These are important for the manufacturing sector as they enable even the most emitting of hard-to-abate activities to reduce their emission intensity. The following activities are covered here:
  - Point-source capture of CO<sub>2</sub>. This activity clarifies the rules for using carbon capture technology within the framework of this taxonomy.
  - Transportation of captured CO<sub>2</sub>. This activity determines the rules for transporting carbon captured in the carbon capture process.

- Permanent sequestration of captured CO<sub>2</sub>. This activity determines the rules for the disposal of carbon captured in industrial and other processes.
- Utilisation of captured CO<sub>2</sub>. This activity determines how the captured CO<sub>2</sub> can and cannot be used.

#### 3. Manufacturing criteria scope

The criteria for manufacture cover a heterogeneous group of activities in nature and technological structure, which will be specifically defined in the respective subchapter.

Eligible expenditure also covers the costs of the facilities and supporting infrastructure associated with the production process. In practice, this means that not only revenues associated with the production of low-carbon cement, or upgrades of facilities are considered aligned with the Taxonomy, but also a project to construct a new cement plant that will produce low-carbon cement is eligible.

#### 4. Manufacturing criteria methodological approach

Unlike the energy sector, which can be decarbonised fairly quickly given the availability of capital, for many high-emitting activities in the manufacturing sector, there is simply no available technology way to do so. All activities in this sector can be divided into five groups:

- Hard-to-abate activities. These are the activities that the economy needs in the long term, but cannot be decarbonised overnight and need gradual decarbonisation;
- Interim (only production of plastics). This activity has a definite role in the economy until 2050<sup>47</sup>, but in their present form must be gradually phased out completely by this date. The main production processes in it should be transformed to such an extent that it is no longer a threat to the fulfilment of the objectives of the Taxonomy.

<sup>&</sup>lt;sup>47</sup> This statement is given for methodological reasons and does not affect the activity cards that serve as the only source of technical screening criteria. Interim activities activity cards are still usable after 2050.

- Enabling activities<sup>48</sup>. Activities in the second category (for example, the production of low-emission cars or batteries) may involve significant emissions, but the products they produce are considered critical for the decarbonisation of the economy as a whole, and thus their emissions are negligible compared to the overall benefit to climate.
- **Related to carbon capture and storage**. These activities help decarbonise the economy by capturing, transporting, and burying carbon that would otherwise be released into the atmosphere.
- Auxiliary transitional activity. This section includes the introduction of energy efficiency and decarbonisation measures in manufacturing activities not specified in the Thailand Taxonomy designed to enable as many businesses as possible to participate in the implementation of the Taxonomy.

Manufacturing sector activities often have complex production chains, and in order to use the Taxonomy it is very important to determine how much of these chains are covered by the criteria. For such activities, the Taxonomy offers the following definitions:

• Activity coverage. These diagrams or descriptions show the parts of an activity's production chain to which the Taxonomy's criteria and thresholds apply. This means that these elements of the production chain can be replaced during the application of the Taxonomy (e.g. through the application of amber-category measures) and funds coloured compliant (as adaptation or green finance) can be requested for them. Chain elements outside of this diagram or description CANNOT be subject to change within the Taxonomy criteria and funding defined by the Taxonomy categories cannot be requested for them.

<sup>&</sup>lt;sup>48</sup> An enabling economic activity should qualify as contributing substantially to one or more of the environmental objectives when it directly enables other activities to make a substantial contribution to one or more of those objectives. Such enabling activities should not lead to a lock-in of assets that undermine long-term environmental goals, considering the economic lifetime of those assets, and should have a substantial positive environmental impact, on the basis of life-cycle considerations: European Union [EU], "REGULATION (EU) 2020/852 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 18 June 2020 on the Establishment of a Framework to Facilitate Sustainable Investment, and Amending Regulation (EU) 2019/2088," Official Journal of the European Union (EU, June 22, 2020), https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32020R0852.

• Scope of emissions calculation. These diagrams or descriptions show how the emission of an activity should be counted to calculate whether or not the activity meets the criteria and thresholds. Typically, the diagrams and descriptions are consistent with the sum of Scope 1 and Scope 2, but sometimes some elements of these scopes are not included because they are not climate-material for the activity. It is important to note that emission calculations are not important in all applications of the Taxonomy, but only when required to determine thresholds. In most cases, it is required to verify that the activity fits the green category, but not the amber or red categories, which are simpler to define and apply.

**Important note 1**: The Taxonomy aims to reduce emissions in sectors that are notable contributors to climate change via GHG emissions. Many other sectors and activities (e.g., textiles, food, paints, etc.) are important to the Thai economy, but are not themselves large emitters of greenhouse gases. Those parts of their value chains that are climate material (mostly production of steel, iron, aluminium, transportation etc.) are included in the relevant sections of the Taxonomy (manufacturing or transportation sections). For activities that do not have their own decarbonisation criteria, the activity "Introduction of energy efficiency and decarbonisation measures in manufacturing activities not specified in the Thailand Taxonomy" has been developed (read details below).

**Important note 2:** At the end of each activity card, there is a 'Criteria reference' line referring to a document that is the methodological basis for the criteria in the activity card (most commonly referring to Climate Bonds Initiative sectoral criteria<sup>49</sup>). These documents and their contents are not part of the criteria, and fulfilment of the conditions specified in these documents is not necessary for compliance with the Thailand Taxonomy. The purpose of this reference is to provide a source of criteria for those who wish to become more familiar with the theoretical and methodological framework, and to provide material for further updating of the criteria when the Taxonomy is revised.

<sup>&</sup>lt;sup>49</sup> Climate Bonds Criteria are used as a major source of reference due to their status as a universal standard applied in the majority of the world's taxonomies

#### 4.1 Hard-to-abate activities

This category includes the production of steel and iron, cement, basic chemicals, aluminium, and hydrogen. Individual decarbonisation trajectories have been developed for the green category for these activities taking into account data provided by Thai ministries and agencies that are in line with the Climate Bonds Initiative Standards Criteria<sup>50</sup>. The trajectory leads to net-zero emissions in 2050. Wherever possible, science-based transition pathways (or methodologies of their creation) have been adopted from other organisations:

- Basic chemicals: Teske et al. (2022); ICF and Fraunhofer ISI study for the EC (2021)
- Cement: Science-Based Targets Initiative
- Basic iron and steel: IEA Net-Zero Emissions (IEA NZE)
- Aluminium: International Aluminium Institute based on IEA
- Hydrogen: MIT Energy Initiative's SESAME platform

In most cases, these pathways were modified in line with the country data provided by relevant Thailand government bodies and professional associations. For more information on calculation of individual decarbonisation pathways please see prefaces for specific manufacturing activities.

As for the amber category, given the scale of challenges associated with the decarbonisation of the selected manufacturing sectors and the lack of technologically and economically feasible low-carbon alternatives, these sectors have been defined as inherently "in transition." While in other sectors it is possible to delineate a boundary between red and amber, for most manufacturing activities, the boundary is harder to define because data is often not available to build a trajectory with any credibility or scientific basis, meaning that the line between ineligible and amber would be arbitrary.

This approach takes into account the objectives set by NDC Thailand wherever possible. It should be noted that the decarbonisation measures themselves (amber category) are not tied to any timeframe other than the sunset date defined by the ASEAN Taxonomy (2040) and can

<sup>&</sup>lt;sup>50</sup> CBI, "The Standard," Climate Bonds Initiative, April 29, 2024, https://www.climatebonds.net/standard/the-standard.

be applied to achieve decarbonisation by any year, either 2050 or 2065, as defined by the current version of Thailand's NDC.

For this reason, specific provisions were introduced for the amber category in this class of activities:

- Introduction of specific decarbonisation measures: individual decarbonisation measures are proposed in order to circumvent the lack of availability of data. The adoption of those technologies acts as a proxy for decarbonisation. Application of these measures helps to reduce the emission intensity of industrial processes and move it closer to the established decarbonisation pathway.
- Transition plans: in order to qualify as transition, a credible transition plan towards net-zero must be adopted at the entity level. This is necessary to ensure that movement towards net-zero is not a one-off push of a single facility, but a consistent strategic course of the manufacturing entity. We recommend for the transition plans to be prepared in line with Transition Finance Principles outlined by the International Platform on Sustainable Finance<sup>51</sup> or ASEAN Transition Finance Guidance<sup>52</sup>.

As for the red activities, they are absent from hard-to-abate subsectors activity cards (except for plastics where the red category includes the production of all types of plastics not mentioned in green or amber category due to their heavy environmental footprint) due to their significant environmental footprint. This is because the nature of this category prevents it from being fully decarbonized in a short time.

#### 4.2 Interim activities

*Financing credible transition* paper<sup>53</sup> by Climate Bonds Initiative defines interim activities as "activities currently needed but should be phased out by 2050 - e.g. recycling of plastics or

<sup>&</sup>lt;sup>51</sup> International Platform of Sustainable Finance [IPSF], "IPSF Transition Finance Report," European Commission (IPSF, November 2022), https://finance.ec.europa.eu/system/files/2022-11/221109-international-platform-sustainable-report-transition-finance en.pdf.

<sup>&</sup>lt;sup>52</sup> ASEAN Capital Markets Forum [ACMF], "ASEAN Transition Finance Guidance," ACMF (ACMF, October 17, 2023), https://www.theacmf.org/images/downloads/pdf/ASEAN%20Transition%20Finance%20Guidance%20Version%201%20-%20FINAL%2017%20Oct%202023.pdf.

<sup>&</sup>lt;sup>53</sup> Climate Bonds Initiative. *Financing Credible Transitions*. London: Climate Bonds Initiative, 2021. https://www.climatebonds.net/files/reports/cbi fincredtransitions final.pdf.

production of energy from municipal waste". Manufacturing sector of the Thailand Taxonomy includes only manufacture of plastics as such an interim activity. The criterion for this activity encourages the recycling of existing plastic by mechanical or chemical means and the subsequent production of new goods from recycled plastic.

#### 4.3 Enabling activities

An enabling activity directly enables other activities to make a substantial contribution to one or more of those objectives. Such enabling activities should not lead to a lock-in of assets that undermine long-term environmental goals, considering the economic lifetime of those assets, and should have a substantial positive environmental impact, on the basis of life cycle considerations. The following activities are considered enabling:

- Manufacture of batteries
- Manufacture of renewable energy technologies
- Manufacture of low-carbon technologies for transport
- Manufacture of energy-efficiency equipment for buildings
- Manufacture of other low-carbon technologies

Because of the intrinsic nature of enabling activities, there is only the green category available and no amber category.

#### 4.4 Carbon capture, transportation, utilisation, and storage

Technologies such as Carbon Capture and Storage (CCS) and Carbon Capture, Utilisation and Storage (CCUS) have significant potential to contribute to the decarbonisation of industry, but only if carbon remains permanently stored and is either securely locked in geological structures or reused for manufacturing processes/durable<sup>54</sup> products manufacturing and does not get back into the atmosphere.

Thus, the green category in CCS/CCUS-related activities is related to the proper handling, transportation, and monitoring of leaks during the capturing process, transportation and

<sup>&</sup>lt;sup>54</sup> The product is considered durable if its expected lifespan is longer than 3 years. Bureau of Economic Analysis. "Durable Goods." *U.S. Department of Commerce*. Accessed March 10, 2025. <u>https://www.bea.gov/help/glossary/durable-goods</u>)

storage of  $CO_2$ , and the amber category is related to the retrofitting of existing pipelines. The thresholds themselves were constructed to match those applied by the European Union Taxonomy.

Captured  $CO_2$  may either be transported and stored or used on-site for other industrial processes that require a source of carbon. Huge quantities of  $CO_2$  are currently used each year, mainly in the fertiliser industry and for enhanced oil recovery (which is not aligned with the objectives of Thailand Taxonomy) while new utilisation pathways in the production of  $CO_2$ -based synthetic fuels, chemicals and building aggregates are gaining momentum.

# 4.5 Auxiliary transitional activity: Introduction of energy efficiency and decarbonisation measures in manufacturing activities not specified in the Thailand Taxonomy

This activity has been specifically designed to allow as many industrial companies as possible to participate in the application of the Taxonomy. It involves the introduction of energy efficiency measures, the electrification of production processes and the replacement of nonrenewable energy sources with renewable ones. The activity can be applied to decarbonise and improve the energy efficiency of all activities that do not have a separate item in the Taxonomy.

This activity was developed specifically for Thailand Taxonomy and has no precedent in other taxonomies. As the wide variation in applications precludes the development of a single best practice for all types of activities, its activities in green category should comply the international standards such as SBTi. The amber category has two options:

- Improve energy efficiency by at least 40% relative to the baseline energy intensity of the facility. This threshold has been defined according to the Draft 2024 Energy Efficiency Plan, which aims to reduce the energy intensity of the Thai economy by 36% by 2037 (compared to 2010 baseline). Adapting this figure to the mechanisms of the taxonomy and the general sunset date (2040), this figure was raised to 40% and extrapolated to the baseline of a particular enterprise.
- Electrification and replacement of energy sources with renewable energy. Electrification is considered by climate science to be one of the most effective ways to decarbonise because it allows access to renewable energy connections. This activity

does not contain any targets or thresholds, as replacing any amount of energy consumption with renewable energy is a contribution to the Taxonomy targets. It is important to note that only the direct connection of an enterprise to renewable energy sources is taken into account, the purchase of PPA certificates is not included, as this does not lead to an actual reduction in the emission intensity of a particular enterprise.

This activity may not be applied to decarbonising industries associated with the extraction, transport or storage of hydrocarbons, or the production of components for these processes, or any other type of industry that promotes the use of hydrocarbons and their derivatives (e.g., prohibited for application to facilities producing internal combustion engine vehicles).

#### 5. Criteria application scheme

Either the financial flows (CapEx and OpEx) associated with a production process or with the entire production facility can qualify as eligible.

The amber category that applies to investment measures (those for hard-to-abate subsectors) cannot be used to assess revenues. It can only be used to define the alignment of CapEx. Such an approach has a major upside in that it rewards individual decarbonisation efforts whilst also facilitating emissions reduction from hard-to-abate sectors in the absence of available data. However, the amber category for these activities has a sunset date of 2040, limiting the timeframe of the eligibility of measures. Following this date, the amber category will no longer be applicable, as the target year for achieving net-zero emissions approaches. All legacy high-emission industries are expected to be progressively phased (all amber activities become out-of-scope after this date). This period aims to offer an opportunity to reward positive climate impacts while low or zero-emission technologies remain underdeveloped and expensive.

	Green	Measures-based	Activity-based
		amber	("traditional") amber
Taxonomy is used to	CapEx is eligible if a	Financing of specific	CapEx is eligible if a
define the alignment	given activity currently	measures (each of	given activity currently
of CapEx	meets the green	them might have	meets the amber
	criteria, and the	additional measure-	criteria, and the
	measure will help to		measure will help to

	Table 2 Usabilit	y implication	of the	measures-based	approach
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	Green	Measures-based	Activity-based
		amber	("traditional") amber
	keep below the future	specific criteria) is	achieve green criteria
	green criteria (so	eligible as amber	(so assume the need to
	assume need to assess		assess transition
	the transition		plan/CapEx plan)
	plan/CapEx plan)		
Taxonomy is used to	Revenue is eligible if	Not available	Revenue is eligible if
define the alignment	the activity meets		the activity meets the
of revenues	green criteria		amber criteria
associated with			
activities.			

Note: this distinction between measures-based and activity-based amber is important for the methodology of the chapter but does not affect application scheme. Only three statuses are available for the taxonomy: green activities, amber activities, and red activities.

### 6. Manufacturing subsector criteria and thresholds

#### 6.1 Hard-to-abate activities

#### 1. Manufacture of basic chemicals

The scope of the activity defined under Thailand taxonomy includes assets and activities involved in the production of a number of eligible organic and inorganic basic chemicals. The eligible basic chemicals that are under the scope of the Taxonomy are defined in Table below.

Table 3. Eligible basic chemicals under the scope of Thailand Taxonomy

Chemical groups	Eligible assets
Inorganic basic chemicals	• Ammonia
	Chlorine
	Disodium carbonate/Soda ash
	Nitric acid
	Carbon black
Organic basic chemicals	High-value chemicals (ethylene, propylene, butadiene)
	• Aromatics BTX (acetylene, benzene, toluene and xylene )
	Methanol

Decarbonisation trajectories for nitric acid, high value chemicals and aromatics BTX were calculated based on the Climate Bonds Initiative methodology, which integrated data provided by the Federation of Thai Industries (FTI). The thresholds for 2025 were calculated as follows: 15% was subtracted from the average emission intensity data for each product type obtained from FTI (to aim for the "best in class" installations), and then the values for 2030 and 2035 were calculated as a proportional reduction in emission intensity to values compliant with the Climate Bonds Basic Chemicals Criteria. Although technologies to decarbonise the chemical industry to Climate Bonds Criteria-aligned thresholds exist today, applying these thresholds only from 2040 onwards will give the Thai chemical industry sufficient time to prepare and make the necessary capital investments.

For ammonia, chlorine, soda ash, carbon black and methanol, their decarbonisation pathways, requirements and thresholds are taken directly from the Climate Bonds Basic Chemicals Criteria and are compliant with the best available technology in the world.

Thresholds and pathways for all mentioned chemicals except chlorine in these criteria are based on the alignment to Paris Agreement-aligned decarbonisation pathways for the entire chemical sector published by Teske et al. (2022)<sup>55</sup> With the reduction rates from Teske et al.'s pathway and taking as basis the thresholds for 2022, the thresholds were extrapolated to 2025 first using the 4.7% annual reduction to have the 2025 base value. Afterwards, the aforementioned reduction rates were applied to calculate the 2030, 2035, 2040, 2045 and 2050 threshold. For nitric acid, high value chemicals and aromatics Teske's values are applied only at 2040 and after.

The value chain of basic chemicals production, along with boundary of production activities within the scope of taxonomy is specified in Figure below.

<sup>&</sup>lt;sup>55</sup> Sven Teske et al., "1.5 °C Pathways for the Global Industry Classification (GICS) Sectors Chemicals, Aluminium, and Steel," SN Applied Sciences/SN Applied Sciences 4, no. 4 (April 1, 2022), https://doi.org/10.1007/s42452-022-05004-0.

Figure 2 Basic Chemicals production value chain and activities within the scope of the Taxonomy criteria



In order to be compliant with green criteria, all important elements of the facility and technological process should correspond to the criteria stipulated in the respective activity card. An overview of that list is given in Figure below.



Figure 3 Green criteria overview for manufacture of basic chemicals

The scope of emissions calculations for the production of the basic chemicals is as follows:

- Nitric acid and soda ash: scope 1 emissions, which include all direct emissions from the production processes, such as emissions generated during the chemical reactions and emissions from fuel combustion on-site.
- Carbon black, high value chemicals and aromatics: scope 1 as defined above plus scope 2 emissions which includes indirect emissions from the energy imported from off-site.

- Methanol and ammonia: associated GHG emissions counted as the life cycle emissions of hydrogen used as feedstock.
- **Chlorine**: only electricity consumption intensity is within the scope. No separate GHG accounting for the whole production process is required for chlorine, as all emissions in its production chain are associated with electricity consumption.

Amber criteria of the activity include decarbonisation measures that are applicable within the basic chemical production facility where the <u>entity has a transition plan aligned with the</u> <u>commitments under the Paris Agreement.</u> The framework for the amber criteria is specified in the Figure below.

#### Figure 4 Amber criteria framework for manufacture of basic chemicals



#### Manufacture of basic chemicals criteria and thresholds

Sector	Manufacturing
Activity	Manufacture of basic chemicals
ISIC code	C201
Description	Production of carbon black, soda ash, chlorine, anhydrous ammonia, nitric acid,
	ethylene, propylene, butadiene, benzene, acetylene, xylene, toluene, methanol
Objective	Climate change mitigation; Resource resilience and circular economy promotion
Green	For the activity of production of a certain listed chemical or a facility as a whole to
	be aligned with the green category of Thailand Taxonomy, it must comply with the
	following requirements:
	• More than 50% of the facility's production (by volume) is made up of
	chemicals included in the scope of the present article (listed in the
	"Description" line under manufacture of basic chemicals criteria and
	thresholds;

	<ul> <li>All activities carried out on the facility that fall within the scope of the present article need to meet specific carbon or energy intensity thresholds defined in <b>Table 4</b> (see below the present activity card);</li> </ul>				
	<ul> <li>Facility operators must check whether Additional requirement 1 or Additional requirement 2 listed below apply to their activities. If yes, these requirements must be further fulfilled.</li> </ul>				
	Additional requirement 1: applicable if the facility is using fossil gas, naphtha, hydrogen, $CO_2$ , or biomass as feedstock. These facilities are eligible only if they meet the following criteria:				
	<ul> <li>Fossil gas or naphtha: only eligible for existing unabated GHG facilities prior to 2040;</li> </ul>				
	<ul> <li>If facilities use biomass or hydrogen as a feedstock source, they should meet Taxonomy's green criteria of these activities;</li> </ul>				
	<ul> <li>CO<sub>2</sub>: satisfies the criteria described in Table 4 (e.g., CO<sub>2</sub> from ammonia production should not be used for urea production).</li> </ul>				
	Additional requirement 2: applicable if the facility uses fossil gas, naphtha, hydrogen, biomass, or heat supplied from alternative sources as a fuel source. These facilities are eligible only if they meet the following criteria:				
	<ul> <li>Fossil gas or naphtha: Only eligible for existing unabated industrial facilities<sup>56</sup> prior to 2040;</li> </ul>				
	<ul> <li>If facilities use biomass or hydrogen as a fuel source, they should meet green criteria of these activities.</li> </ul>				
	Facilities using heat supplied from alternative sources, such as geothermal, solar thermal, and waste heat recovery: The heat source must comply with the green category of the Taxonomy's most up-to-date criteria for each source of energy.				
Amber	In order to be aligned with the amber category, the manager of the facility must implement at least one of the measures mentioned in <b>Table 5</b> . By implementing this measure, the manager of the activity must, as a minimum, achieve the result indicated in the "Mitigation criteria" column of <b>Table 5</b> . If the application of the				

<sup>&</sup>lt;sup>56</sup> Unabated industrial facilities refer to industrial plants that continue to emit greenhouse gases without implementing significant mitigation measures, such as carbon capture, utilization, and storage (CCUS), or other technologies aimed at reducing greenhouse gas emissions.

	listed measure does not lead to the result indicated in the column, the application			
	of this measure cannot be considered eligible. In addition:			
	<ul> <li>Eligible decarbonisation measures or retrofitting activities (CapEx) should be implemented prior to the designated subset date (2040)</li> </ul>			
	<ul> <li>More than 50% of the facility's production is made up of chemicals</li> </ul>			
	included in the scope of the present article (listed in the "Description"			
	line under manufacture of basic chemicals criteria and thresholds);			
	• A company that owns the facility should have a transition plan aligned			
	with the commitments under the Paris Agreement and/or net zero GHG			
	emissions target of Thailand.			
Red	Activities that do not comply with the green or amber category are harmful to the			
	objective of climate change mitigation.			
Criteria reference	<u>Climate Bonds Basic Chemicals Criteria</u>			

# Table 4 Basic chemicals decarbonisation pathways<sup>57</sup>

Asset type	2025	2030	2035	2040	2050
Production of	• Uses hydrogen as feedstock that meets the Taxonomy criteria for hydrogen production (green				
ammonia	category) OR ammonia is recovered from wastewater.				
	AND				
	• CO <sub>2</sub> from ammonia production should not be used for urea production.				
Production of	0.527	0.263	0.131	0.007	0
nitric acid <sup>58</sup> (t					
CO <sub>2</sub> e /t nitric acid)					
Production of	2.45 MWh	1.85 MWh	Carbon intensity of electricity used meets the Taxonomy		
chlorine	electricity/t	electricity/t	criteria for electricity generation (green category)		
	chlorine	chlorine			
	OR	OR			
	carbon	carbon intensity			
	intensity of	of the electricity			
	the electricity	used meets the			
	used meets	Taxonomy criteria			
	the Taxonomy	for electricity			
	criteria for	,			
	electricity				

<sup>&</sup>lt;sup>57</sup> CBI, "Basic Chemicals Criteria", April, 2023 https://www.climatebonds.net/files/files/standards/Chemicals%20-

<sup>%20</sup>Basic/Sector%20Criteria%20-%20Basic%20Chemicals%20%28April%202023%29.pdf

<sup>&</sup>lt;sup>58</sup> Modelled proxy data is used here instead of real data due to limited availability. The number will be updated in the future.

Asset type	2025	2030	2035	2040	2050
	generation (green category)	generation (green category)			
Production of carbon black (t CO <sub>2</sub> e/t carbon black)	1.141	0.63	0.34	0.20	0
Production of disodium carbonate/soda ash	0.789 t CO2e/t disodium carbonate/ soda ash AND carbon intensity of the electricity used meets the Taxonomy criteria for electricity generation (green category)	0.44 t CO <sub>2</sub> e/t disodium carbonate/ soda ash AND carbon intensity of the electricity used meets the Taxonomy criteria for electricity generation (green category)	0.23 t CO <sub>2</sub> e/t disodium carbonate/ soda ash AND carbon intensity of the electricity used meets the Taxonomy criteria for electricity generation green category)	0.14 t CO <sub>2</sub> e/t disodium carbonate/ soda ash AND carbon intensity of the electricity used meets the Taxonomy criteria for electricity generation (green category)	0 t CO <sub>2</sub> e/t disodium carbonate/ soda ash AND carbon intensity of the electricity used meets the Taxonomy criteria for electricity generation (green category)
Production of high-value chemicals (ethylene, propylene, butadiene) <sup>59</sup>	0.77	0.68	0.60	0.43 in 2040 and 0.26 in 2045	0.09
Production of aromatics BTX <sup>60</sup>	0.348	0.174	0.087	0.0012	0

<sup>&</sup>lt;sup>59</sup> The data and decarbonization pathway on the production of high-value chemicals (ethylene, propylene, butadiene) have been obtained from the Petrochemical Industry Club, the Federation of Thai Industries. As the data is sample data from Thai producers, the pathway will be considered once more comprehensive data becomes available and/or significant technological advancements.

<sup>&</sup>lt;sup>60</sup> The current GHG data on the production of aromatics BTX (only benzene, xylene, and toluene) has been obtained from the Petrochemical Industry Club, the Federation of Thai Industries. Due to the data limitation of Thai manufacturers in

Asset type	2025	2030	2035	2040	2050
(acetylene, benzene, xylene,					
and toluene) (t					
CO <sub>2</sub> e/t aromatics					
BTX)					
Production of	Uses hydrogen as feedstock that meets the Taxonomy criteria for hydrogen production (green				
methanol	category)				

#### Table 5 Decarbonisation measures for the chemical industry<sup>61</sup>

Area	Activity	Mitigation criteria
Energy efficiency	Revamps, modifications, or	At least a 30 % improvement in
measures	acquisition of equipment (boilers,	energy efficiency.
	furnaces, reactors, heat exchanger,	
	distillation columns and other	
	separation units, etc.)	
Switching to low-carbon	Revamps, modification and	The technology does not release
process technologies	acquisition of equipment and other	direct process CO <sub>2</sub> emissions, e.g.,
	infrastructure needed for the	methane pyrolysis catalytic partial
	implementation and operation of	oxidation of methane to methanol.
	low carbon process technologies.	
Carbon Capture and	Infrastructure related to CO <sub>2</sub>	• The minimum capture rate
Storage (CCS)	capture of emissions from the	from the entire facility should
	basic chemicals production,	be 90% (capture only,
	transportation, and storage	without transportation or
		storage).
		• There is evidence <sup>62</sup> that
		demonstrates the CO <sub>2</sub> will be
		suitably transported and
		stored in line with the

specific product categories, proxy data is used for pathway calculations. A data review will be considered once more comprehensive data becomes available and/or significant technological advancements.

<sup>&</sup>lt;sup>61</sup> CBI, "Basic Chemicals Criteria", April, 2023 https://www.climatebonds.net/files/files/standards/Chemicals%20-

<sup>%20</sup>Basic/Sector%20Criteria%20-%20Basic%20Chemicals%20%28April%202023%29.pdf

<sup>&</sup>lt;sup>62</sup> Either directly from the issuer or through contracts or agreements with a third party

Area	Activity	Mitigation criteria	
		Taxonomy criteria (green	
		category)	
	d		
Using hydrogen as a	Infrastructure for production using	Hydrogen used as a feedstock	
feedstock	hydrogen that is aligned with the	meets the thresholds set out in	
	Thailand Taxonomy (green	the Taxonomy for green category	
	category)	(green category)	
	OR		
	Refurbishment and retrofitting of		
	facilities to use hydrogen that is		
	aligned with the Thailand		
	Taxonomy (green category)		
	OR		
	Acquisition of equipment to		
	produce basic chemicals using		
	hydrogen that is aligned with the		
	Thailand Taxonomy (green		
	category)		
Using biomass as a	Infrastructure for production using	The biomass used complies with	
feedstock	biomass	the criteria applicable for biomass	
	OR	sourcing set out in the Taxonomy	
	Refurbishment and retrofitting of	Bio-energy criteria (green category)	
	facilities to use biomass		
	OR		
	Acquisition of equipment to		
	produce basic chemicals using		
	biomass		
Using CO <sub>2</sub> as a	Infrastructure for production using	1. The source of $CO_2$ sources is	
feedstock <sup>63</sup>	CO <sub>2</sub> as a feedstock	either:	
	OR	• Direct emissions from	
	Refurbishment and retrofitting of	chemical production; OR	
	facilities to use CO <sub>2</sub> as a feedstock	• Direct emissions from other	
	OR	industrial activities	

 $<sup>^{\</sup>rm 63}$  Please refer to Waste management sector for more details
Area	Activity	Mitigation criteria		
	Acquisition of equipment to	2. The basic chemical produced is		
	produce basic chemicals using CO <sub>2</sub>	used for the manufacture of		
	as a feedstock	durable products (e.g. construction		
		materials stored in buildings or		
		recyclable products, e.g. PET).		
		3. If the basic chemical produced is		
		used for products that release $CO_2$		
		immediately when the products		
		are used (such as in urea,		
		carbonated beverages, or fuels),		
		the capital investment is not		
		eligible.		
		4. $CO_2$ is not used for enhanced oil		
		recovery, and the production of		
		other forms of fossil energy		
		sources.		
		5. This measure may involve the		
		need for electricity when		
		electrochemical processes are		
		used, and also the need for		
		hydrogen as a feedstock. If so, that		
		hydrogen must comply with the		
		Taxonomy criteria (green category)		
Use of recycled material	Infrastructure for the production	Recycled material should:		
as feedstock (e.g. using	using recycled feedstock	• represent at least 20% of the		
olefins recovered from	OR	feedstock in regions without		
plastics chemical	Refurbishment and retrofitting of	local recycling regulations or		
recycling processes)	facilities using recycled feedstock	with lower recycled content		
	OR	requirements.		
	Acquisition of equipment to	• represent more than 20% of		
	produce basic chemicals using	the feedstock in regions with		
	recycled feedstock	local recycling regulations. If		
		the region has a higher		
		recycled content percentage,		
		it should prevail.		

Area	Activity	Mitigation criteria	
		• have lower cradle-to-gate	
		emissions than the virgin	
		material	
		OR	
		Recycled feedstock is certified by	
		International Sustainability and	
		Carbon Certification (ISCC)	
	Relating to energy used		
Electrification of the	Revamps, modifications, and	Electricity must be low-carbon and	
processes	acquisition of equipment (furnaces,	comply with the most up-to-date	
	reactors, separators, etc.) and other	Taxonomy criteria for electricity	
	infrastructure necessary for	grids (green category)	
	electrification of the processes		
Heat supplied from	New heat exchange equipment,	Heat supply complies with the	
geothermal, solar	such as evaporators, furnaces,	most up-to-date Taxonomy criteria	
thermal or waste heat	boilers, etc.,	for the relevant source of energy	
recovery systems	OR	(green category)	
	Revamps or modifications to		
	heating-related equipment in the		
	existing process		
Using hydrogen as an	Revamps or modifications to	The hydrogen to be used meets	
energy source	equipment (boilers, furnaces,	the Taxonomy criteria for hydrogen	
	burners, etc.) in existing utility	production (green category)	
	systems required for the use of		
	hydrogen as fuel		
	OR		
	Infrastructure for the production of		
	a basic chemical in scope using		
	hydrogen as an energy source		
Using biomass or biogas	Revamps or modifications to	The bioenergy complies with the	
as an energy source	equipment (boilers, furnaces,	Taxonomy Bio-energy criteria	
	burners, etc.) in existing utility	(green category). Primary organic	
	systems required for the use of		
	biomass as fuel		
	OR		

Area	Activity	Mitigation criteria
	Infrastructure for the production of	streams <sup>64</sup> are only eligible if
	a basic chemical in scope using	certified as sustainable by
	biomass as an energy source	Roundtable on Sustainable
		Biomaterials or International
		Sustainability and Carbon
		Certification. Wood is eligible only
		if produced on a sustainable
		plantation as defined by the
		Thailand Taxonomy's Forestry
		Criteria when using biomass as a
		reducing agent and/or for energy
		generation.

## 2. Manufacture of cement

Decarbonisation trajectories for cementitious products were calculated according to data provided by Thai Cement Manufacturers Association (TCMA). TCMA has adopted Thailand 2050 Net Zero Cement and Concrete Roadmap <sup>65</sup>, compliant with the Paris Climate Agreement and assuming full decarbonisation of the sector by 2050.

The scope of the activity included under Thailand Taxonomy covers assets and activities involved in the production of cement, with the scope boundary beginning at the quarry of limestone and ending at the final blended cement product. The quarrying activity is included in the scope only if it is integrated into the same geographical location as cement production facilities and operations (separate quarries can't be assessed against the Taxonomy). The cement production facilities themselves may be integrated from quarries to blended cement, or they may be responsible for only one stage of production, for example, clinker production, grinding, or blending. The boundary is illustrated in the figure below

<sup>&</sup>lt;sup>64</sup> Primary organic streams or sources are those which come directly from the land and without having undergone any processing, apart from cleaning. They maintain all the biological qualities they had when they were still on the plants. Secondary organic streams or sources are those that have undergone processing or have been used.

<sup>&</sup>lt;sup>65</sup> Thai Cement Manufacturers Association. *Thailand 2050 Net Zero Cement & Concrete Roadmap*. Bangkok: Thai Cement Manufacturers Association, October 2024. <u>https://www.thaicma.or.th/en/ebook\_detail/3/197</u>



## Figure 5 Cement production activities within the scope of the Taxonomy criteria

Apart from the activities defined in the boundary in the figure above, the activities and assets in the cement production value chain that are **out of the scope** of the Taxonomy activity are as follows:

- **Production of fly ash and blast furnace slag**: Production of these through coal power or steel production is not eligible. However, the processing of such materials extant from a power plant that no longer functions can be eligible.
- **Concrete**: the production of concrete itself and associated activities (mix design, mixing itself, transportation to site, quality control, etc.) are out of scope.
- Quarrying: quarrying in and of itself (i.e., that is separate from a cement plant or is a pure-play quarry company) is not within scope.

Additionally, the entities in the cement production value chain that are <u>out of the scope</u> of the Taxonomy activity are as follows:

- **Pureplay concrete producers:** Companies whose sole activity is the production of concrete itself and associated activities (mix design, mixing itself, transportation to site, quality control, etc.).
- **Pureplay quarrying companies:** Companies whose sole activity is quarrying (i.e., separate from a cement production company).
- **Pureplay clinker production companies:** Companies that solely produce clinker, which is then sold downstream for further processing into cement. Note: companies that produce clinker and cement are within the scope of a company that purchases clinker.

In order to be compliant with green criteria, all important elements of the facility and technological process should correspond to the criteria stipulated in the respective activity card. An overview of that list is given in the figure below.



Figure 6 Green criteria framework for manufacture of cement

The facility level emission intensity threshold is in terms of t  $CO_2/$  t cementitious product or t  $CO_2/$  t cement (equivalent), wherein "cementitious product" means clinker, cement and cement substitutes produced by the reporting entity.

The scope of emissions that must be covered when assessing compliance with the Taxonomy is detailed in the figure below and includes the following:

# • Direct (scope 1) emissions from cement production

- Burning fossil fuels to heat kilns (thermal emissions);
- Calcination emissions (process emissions);
- Emissions from alternative fuels and raw materials;
- On-site power generation.
- Indirect (scope 2) purchased energy emissions.
  - Purchase of electricity, steam, heat, or cooling.
- Off-site (scope 3) indirect impacts in the value chain not owned or controlled by the reporting entity (upstream)
  - As the carbon intensity of the final cement product is the metric, facilities responsible for one specific production stage (for example, grinding facilities) must partially incorporate scope 3 emissions;
  - However, this is only scope 3 emissions up to the point of the finished cement, not downstream emissions associated with transporting or using the clinker/cement product.



Figure 7 Emission boundary for meeting the thresholds of manufacture of cement activity card

Amber criteria of the activity include decarbonisation measures that are applicable within the cement production facility where the entity <u>has a transition plan aligned with the</u> <u>commitments under the Paris Agreement.</u> These eligible decarbonisation measures or retrofitting activities (capital investments) must be implemented prior to a defined sunset date of 2040.

Sector	Manufacturing
Activity	Manufacture of cement
ISIC code	2394
Description	Production of cementitious products
Objective	Climate change mitigation
Green	For the cement production activity to be aligned with the Taxonomy, the activities
	need to meet specific emissions intensity thresholds for cementitious products
	defined in Table: Cementitious products decarbonisation pathway.
	Additional requirement to align with other activities in Thailand Taxonomy:
	• If facilities use biomass or hydrogen as a fuel source, they should meet the
	green criteria for these activities.
	• If facilities use waste as a fuel source, including municipal solid waste, they
	should meet the following criteria:

## Manufacture of cement criteria and thresholds

	<ul> <li>Align with the green criteria in waste management sector</li> </ul>
	<ul> <li>Maximum of waste of recycling potential<sup>66</sup> must be removed prior to</li> </ul>
	burning;
	<ul> <li>Municipal solid waste will not be eligible as a fuel type after 2050.</li> </ul>
	• If the plant uses CCS/CCUS equipment on site, it should meet the green
	criteria of CCS/CCUS.
Amber	Eligible decarbonisation measures or retrofitting activities (capital investments) must:
	• Be implemented prior to 2040 (sunset date);
	• Constitute one or more of the following actions:
	- Installation, upgrade, and operation of pre-calciners;
	- Installation, upgrade, and operation of heat recovery systems;
	<ul> <li>Installation, upgrade, and operation of digitised control equipment or infrastructure. This may include:</li> </ul>
	<ul> <li>Sensors and measurement tools (including software to allow real- time and close control of processes to improve efficiency);</li> </ul>
	<ul> <li>Communication and control (including advanced software and control rooms and automation of plant processes).</li> </ul>
	<ul> <li>Installation, upgrade, and operation of testing equipment. For example (but not limited to):</li> </ul>
	<ul> <li>Automated X-ray diffractometer systems</li> </ul>
	- Electrification of heat (for example, electrified kiln processes);
	<ul> <li>Installation, upgrade, retrofit and operation of measures which achieve emissions savings equivalent to the emissions decrease for facilities over the lifespan of the debt instrument;</li> </ul>
	<ul> <li>Installation, upgrade, and operation of carbon capture and storage equipment that is aligned with Taxonomy criteria for CCS/CCUS: Point- source capture of CO<sub>2</sub> (green category);</li> </ul>

<sup>&</sup>lt;sup>66</sup> A list of waste of recycling potential can be found here or similar Thailand definition can be used: "How Do I Recycle Common Recyclables | US EPA," US EPA, December 1, 2023, https://www.epa.gov/recycle/how-do-i-recycle-commonrecyclables.

	- Infrastructure, revamps, or modifications of equipment needed for the
	production of cement using hydrogen as a fuel that is aligned with
	Taxonomy criteria for hydrogen (green category).
	• The facility must have net-zero plan aligned with the commitments under
	the Paris Agreement.
Red	Activities that do not comply with the green or amber category are harmful to the
	objective of climate change mitigation.
Criteria Reference	<u>Climate Bonds Cement Criteria</u>

### Table 6 Clinker decarbonisation pathway

Year	2025	2030	2035	2040	2045	2050
Carbon intensity						
(t CO <sub>2</sub> / t cementitious or t	0.654	0.543	0.418	0.293	0.147	0
cementitious product)						

## 3. Manufacture of basic iron and steel

International Energy Agency Net-Zero Emissions (IEA NZE)<sup>67</sup> decarbonisation pathway adjusted in line with the Climate Aligned Finance Framework for Steel<sup>68</sup> approach has been utilised to construct these criteria. The IEA NZE Benchmark utilised by the Sustainable STEEL Principles is a modified version on the "Net Zero by 2050" scenario published by the IEA in 2021, with the following modifications:

- Yearly emissions and scrap utilisation data was interpolated using the decadal emissions and scrap utilisation data published by the IEA in the "Net Zero by 2050" report;
- Scope 1 emissions were taken directly from the IEA's "Net Zero by 2050" report, while Scope 2 emissions were estimated using the technology shares of total production included in the report paired with the corresponding emissions factors included in the Mission Possible Partnership model<sup>69</sup>.

<sup>&</sup>lt;sup>67</sup> IEA, "Iron & Steel - IEA," n.d., https://www.iea.org/energy-system/industry/steel.

<sup>&</sup>lt;sup>68</sup> Climate Alignment, "Sustainable Steel Principles Framework," June 2022,

https://climatealignment.org/wpcontent/uploads/2022/06/sustainable\_steel\_principles\_framework.pdf.

<sup>&</sup>lt;sup>69</sup> "Steel," Mission Possible Partnership, n.d., https://www.missionpossiblepartnership.org/action-sectors/steel/.

The scope of the activity involves assets and activities associated with the production of basic iron and steel, with the scope boundary beginning at the raw material preparation stage and ending at the final steel product coming out of the rolling and coating stages. The stages of steel production that are under the scope of the Taxonomy are defined in the figure below.





Apart from the activities and facilities defined in the figure 8, the activities and assets in the cement production value chain that are **<u>out of scope</u>** are as follows:

- **Iron mining:** Mining in and of itself (i.e., separate from a steel plant) is not certifiable under these criteria;
- **Coal mining:** a coal mine cannot be certified. However, producers using coal need to comply with the additional qualitative criteria specific to the use of coal;
- Steel alloying (alloying is not a climate-material process that can be separated from steelmaking);
- Steel scrap collection and sorting (it is defined by the Waste Sector);
- Raw material preparation and downstream processes: assets and activities dealing solely with the production of coke, iron ore pellets and other raw materials that are not part of an iron or steel production facility are out of the scope, as are assets only dedicated to downstream activities such as rolling, and finishing.

Additionally, the entities in the basic iron and steel production value chain that are <u>out of</u> <u>scope</u> are as follows:

- **Pureplay iron ore mining companies:** companies whose sole activity is the mining of iron ore (i.e., separate from a steel production company);
- **Pureplay coal companies:** companies whose sole activity is coal mining (i.e., separate from a steel production company);
- Pureplay stainless and high alloy steels production companies: companies whose sole activity is the production of stainless and high alloy steels and associated activities;
- **Pureplay steel scrap collection and sorting companies:** Companies whose sole activities are the collection and sorting of steel scrap.

### Usability notes

In order to be aligned with the green category, steel facilities must comply with two sets of criteria: facility-specific (based on the major technological process utilised by the facility, for example blast furnace or direct reduction of iron facilities) and cross-cutting (related to feedstock used by the facility regardless of the main technological process utilised on it). Since steel production facilities can operate for many years, new facilities should already be built with  $CO_2$  emissions mitigation technologies in place or avoid  $CO_2$  generation entirely by limiting the use of fossil fuels. The technical challenges are such that this is very important at the design stage – if a plant is not designed to have, for example, CCS/CCUS implemented, it is very difficult to retrofit later.

The amber criteria of the activity include decarbonisation or retrofitting measures that are applicable within the steel production facility. To acknowledge and promote the decarbonisation efforts, new and existing facilities that do not meet criteria designed for the green category at the outset but have been designed to envisage full alignment over time and by 2040 at the latest can be classified as amber. Apart from that, a measures-based approach is also included.

#### Manufacture of basic iron and steel criteria and thresholds

Sector	Manufacturing
Activity	Manufacture of basic iron and steel
ISIC code	2410
Description	Operations of conversion by reduction of iron ore in blast furnaces and oxygen
	converters or of ferrous waste and scrap in electric arc furnaces or by direct
	reduction of iron ore without fusion to obtain crude steel, which is smelted and
	refined in a ladle furnace and then poured and solidified in a continuous caster
	in order to produce semi-finished flat or long products
Objective	Climate change mitigation
Green <sup>70</sup>	In order to be eligible as green, activities and facilities where they take place must comply with all of the following:
	• Applicable facility-specific mitigation criteria ( <b>Table 7</b> )
	• Applicable cross-cutting criteria ( <b>Table 8</b> )
	Facilities using hydrogen as a fuel or reductive agent are eligible only if hydrogen
	complies with Taxonomy criteria for hydrogen (green category)
Amber	<b>Option 1</b> Eligible facilities and assets that are mentioned in <b>Table 7</b> but do not meet the criteria identified in this table can be classified as amber only if (must comply with all criteria):
	<ul> <li>The facility has been designed to and is implementing all necessary actions to meet the criteria for the green category by 2040 at the latest;</li> <li>The facility, from the onset of its operations, is using CCS/CCUS, which operates to capture at least 20% of emissions;</li> <li>A facility has a transition plan aligned with the commitments under the Paris Agreement.</li> </ul>
	<ul> <li>Option 2 Specific technological measures can be implemented to decarbonise steel and iron production if they:</li> <li>are implemented prior to the sunset date (2040);</li> <li>enable the eligible assets to meet the criteria identified in Table 7</li> </ul>
	(examples of compliant measures are listed in <b>Table 8);</b>

<sup>&</sup>lt;sup>70</sup> Green activity threshold does not require any specific decarbonisation threshold as emission is limited by the technical solutions suggested for each particular facility type

	• comply with applicable cross-cutting criteria listed in <b>Table 8</b> .
Red	Activities that do not comply with the green or amber category are harmful to the objective of climate change mitigation. CCUS for the production of products that release CO <sub>2</sub> immediately when these are used (such as in urea, carbonated beverages, or fuels), for enhanced oil recovery, and the production of other forms of fossil energy sources is harmful to the objective of climate change mitigation.
Criteria Reference	<u>Climate Bonds Steel Criteria</u>

# Table 7 Eligible basic iron and steel production facilities

Facility technology	Facility-specific mitigation criteria	
type (eligible assets)		
BF-BOF (Blast Furnace	<ul> <li>Has to have CCS/CCUS meeting taxonomy criteria for CCS/CCUS;</li> </ul>	
– Basic Oxygen	• CCS/CCUS should capture at least 70% of all emissions.	
Furnace)		
Smelting reduction	<ul> <li>Has to have CCS/CCUS meeting Taxonomy criteria for CCS/CCUS;</li> </ul>	
	• CCS/CCUS should capture at least 70% of all emissions.	
Direct Reduced Iron	If fossil gas-based:	
(DRI)	<ul> <li>Has to have CCS/CCUS meeting Taxonomy criteria for CCS/CCUS;</li> </ul>	
	• CCS/CCUS should capture at least 70% of all emissions.	
	If 100% hydrogen-based:	
	• hydrogen meets carbon intensity thresholds and specific Taxonomy	
	criteria for hydrogen (green category).	
Electric Arc Furnace	<ul> <li>Needs to use 70% of scrap as total annual inputs;</li> </ul>	
(EAF)	OR	
	• The combined scrap and (100%) hydrogen-based DRI meeting	
	taxonomy criteria for DRI (green category) should add to at least	
	70% of the EAF's total annual inputs.	
DRI – EAF	If fossil gas-based:	
	<ul> <li>Has to have CCS/CCUS meeting taxonomy criteria for CCS/CCUS;</li> </ul>	
	• CCS/CCUS should capture at least 70% of all emissions.	
	If 100% hydrogen-based:	
	• hydrogen meets carbon intensity thresholds and specific taxonomy	
	criteria for hydrogen (green category).	

Eligible assets	Cross-cutting mitigation criteria	
Facilities that use fossil gas	Using fossil gas both as a reducing agent and for energy generation is	
as a reducing agent and/or	only eligible for existing facilities prior to 2040. To qualify after 2040,	
for energy generation	such facilities would have to use fossil gas combined with CCS/CCUS	
	measures that meet the Taxonomy criteria for CCS/CCUS and:	
	• Utilisation of direct CO <sub>2</sub> emissions from steel production is used for	
	the manufacture of durable products and does not lead to	
	enhanced oil recovery and the production of other forms of fossil	
	energy sources.	
	• Projects using fossil gas (even if) combined with CCS/CCUS should	
	demonstrate that on-site activities: MRV (Monitoring, Reporting and	
	Verification), and mitigation measures for methane leaks as per the	
	best practice recommended <sup>71</sup> . Any venting or burning within the	
	limits of the steel plant shall be avoided, except in emergency	
	situations, in such case it shall be reported and accounted for in	
	the GHG assessment.	
	• Projects using fossil gas (even if) combined with CCS/CCUS should	
	demonstrate that upstream activities provide evidence of having	
	MRV (Monitoring, Reporting and Verification) and mitigation	
	measures for methane leaks as per the best practice	
	recommended <sup>72</sup> .	
Facilities that use coal as a	Using coal, both as a reducing agent and fuel in the steelmaking	
reducing agent and/or for	process, is only eligible for existing facilities prior to 2040. After 2040,	
energy generation	facilities would have to use coal combined with CCS/CCUS measures	
	that meet the Taxonomy criteria for CCS/CCUS and utilisation of direct	
	$\rm CO_2$ emissions from steel production is used for the manufacture of	
	durable products and does not lead to enhanced oil recovery and the	
	production of other forms of fossil energy sources.	

#### Table 8 Cross-cutting criteria for basic iron and steel

<sup>&</sup>lt;sup>71</sup> Best practice can be found in the report: Best Practice Guidance for Effective Methane Management in the Oil and Gas Sector. Monitoring, Reporting and Verification (MRV) and Mitigation. United Nations Economic Commission for Europe. 2019: United Nations Economic Commission for Europe, "Best Practice Guidance for Effective Methane Management in the Oil and Gas Sector," ECE ENERGY SERIES (UNITED NATIONS, 2019),

https://unece.org/fileadmin/DAM/energy/images/CMM/CMM\_CE/Best\_Practice\_Guidance\_for\_Effective\_Methane\_Manageme nt\_in\_the\_Oil\_and\_Gas\_Sector\_Monitoring\_Reporting\_and\_Verification\_MRV\_and\_Mitigation-\_FINAL\_with\_covers\_.pdf <sup>72</sup> ibid

Eligible assets	Cross-cutting mitigation criteria	
	Projects using coal should demonstrate the following:	
	Upstream activities: Provide evidence of having MRV (Monitoring,	
	Reporting and Verification) in place, as well as mitigation measures	
	for methane leaks as per the best practice recommended <sup>73</sup> .	
Facilities that use biomass	Facilities using biomass as a reducing agent are only eligible if they use	
as a reducing agent	the following sources of biomass:	
	• Food or feed crops: If food crops are used, they must be certified	
	as a renewable feedstock (defined as feedstock certified by	
	Roundtable on Sustainable Biomaterials or International	
	Sustainability and Carbon Certification)	
	Plantation wood: the wood plantation shall demonstrate to meet	
	the requirements set out for "Forestry plantation" activities of the	
	Taxonomy.	
	<ul> <li>Industrial crops.</li> </ul>	
	AND	
	Primary organic streams <sup>74</sup> are only eligible as fuel if certified as	
	sustainable by Roundtable on Sustainable Biomaterials or International	
	Sustainability and Carbon Certification. Wood is eligible only if produced	
	on a sustainable plantation as defined by the Thailand Taxonomy's	
	Forestry Criteria.	
Facilities using CCS/CCUS	Facilities using CCS/CCUS are only eligible if the CCS/CCUS meets	
	Taxonomy criteria for CCS/CCUS and utilisation of direct $CO_2$ emissions	
	from steel production is used for the manufacture of durable products	
	(e.g., construction materials stored in buildings or recyclable products,	
	e.g., PET). $CO_2$ should not be used for products that release the $CO_2$	
	immediately when these are used (such as in urea, carbonated	
	beverages, or fuels), nor for enhanced oil recovery and the production	
	of other forms of fossil energy sources.	

<sup>&</sup>lt;sup>73</sup> ibid

<sup>&</sup>lt;sup>74</sup> Primary organic streams or sources are those which come directly from the land and without having undergone any processing, apart from cleaning. They maintain all the biological qualities they had when they were still on the plants. Secondary organic streams or sources are those that have undergone processing or have been used.

Eligible Assets	Facility-specific mitigation criteria
Optimisation of electric	Implement decarbonisation measures that:
arc furnaces, installation	• enable the facility to increase the scrap total annual input;
and operation of other	OR
mitigation measures	• enable the facility to increase the share of renewable energy
associated with EAF	used by the facility.
facilities	
Measures associated to a	<ul> <li>No relining;</li> </ul>
production line with a	• The emissions intensity of the facility should be below 1.8
blast furnace (BF)	tCO <sub>2</sub> /t steel by 2040;
	<ul> <li>Decarbonisation measures should decrease emissions (tCO<sub>2</sub>/t</li> </ul>
	steel) between 2024 and 2040 by:
	- by 15% if emissions < 2.0 tCO $_2$ /t steel and if the production
	line with BF became operational in 2007 or later;
	OR
	- by 20% if emissions >2.0 tCO $_2$ /t steel and if the production
	line with BF became operational in 2007 or later;
	OR
	- at least 50% of the production line with BF became
	operational prior to 2007.
Measures associated with	• Implement decarbonisation measures to decrease emissions
a production line with a	(tCO <sub>2</sub> /t steel) between 2024 and 2040 by:
DRI or smelting reduction	- If fossil gas based: 20%;
	OR
	- If coal based: 40%.
Installation of CCS/CCUS	CCS/CCUS must meet relevant CCS/CCUS criteria from Thailand
	Taxonomy
Measures involving	Biomass and bioenergy must meet relevant criteria from Thailand
biomass or bioenergy	Taxonomy.
Measures involving the	Hydrogen must meet relevant hydrogen criteria from Thailand
use of hydrogen	Taxonomy.

# Table 9 Criteria for capital investments in decarbonisation measures for steel facilities

Table 10 A non-exhaustive exemplary list of decarbonisation measures that comply with the amber category

Asset and activity types	Example of compliant CapEx
Heat recovery	Installation, upgrade, and operation of heat recovery systems
Optimisation of blast furnace	Pulverise coke injection, top gas recycling, stove waste
	gas heat recovery
Optimisation of basic oxygen	Recovery of basic oxygen furnace gas and sensible heat
furnace	
Optimisation of coke plant	Coke dry quenching
Optimisation of sinter plants	Sinter plant heat recovery
Optimisation of EAF	Oxyfuel burners, EAF scrap preheating, CHP from waste heat
Optimisation of rolling	High-efficiency burner, flue-gas monitoring, combustion optimisation,
finishing and reheating	exhaust gas heat recovery
furnace	
Optimisation of casting	Near net-shape casting
Optimisation of monitoring	Installation, upgrade, and operation of advanced sensors and digitised
and control systems	control equipment and systems
Carbon capture and storage	Installation, upgrade, and operation of infrastructure and equipment
(CCS)	related to $CO_2$ capture of emissions from steel production.
Fuel switching	Infrastructure revamps or modifications of equipment needed for the
	production of steel using hydrogen or biomass as a reducing agent
Electrification of heat	Electrification of reheating furnacing

## 4. Manufacture of aluminium

Aluminium is a critical metal with applications in a multitude of renewable energy technologies. Its special characteristic is that it can be recycled and reused without any loss of quality, and these criteria maximise the incentives for the use of recycled aluminium and its recycling.

Under the present criteria, both the aluminium production process and the financial flows associated with it (revenues), as well as the entire aluminium-producing enterprises that meet the parameters, can be verified.

Figure 9 Scope of activities covered by the manufacture of aluminium criteria (primary aluminium)



Scoping for the production of secondary aluminium is not included as secondary aluminium is automatically aligned with the taxonomy without any additional criteria or requirements.

It is important to note that decarbonisation of the aluminium production chain is possible both in the case of primary aluminium production and secondary aluminium production (e.g., a project to replace generating capacity from hydrocarbon generation to renewable generation). This, however, is not a mandatory requirement.

Scoping boundaries for GHG calculation include scope 1 and scope 2 as defined by the International Aluminium Institute<sup>75</sup>:

- Scope 1: Fuel combustion in furnaces/boilers on-site, Coke calcination, Anode production, Anode consumption, PFC emission, Lime production
- Scope 2: Emissions from purchased electricity, heat, or steam

<sup>&</sup>lt;sup>75</sup> International Aluminium Institute, "The Aluminium Sector Greenhouse Gas Protocol," 2006, https://ghgprotocol.org/sites/default/files/2023-03/aluminium\_1.pdf.

Figure 10 GHG emission calculation scope for manufacture of aluminium activities (primary aluminium)



Scoping for the production of secondary aluminium is not included as secondary aluminium is automatically aligned with the taxonomy without any additional criteria or requirements.

## Methodological approach

The main emissions from aluminium production are emitted during electricity generation (60%). A further 15% or so are emitted from the combustion of fuel directly at the smelter, and a further 15% from physical and chemical processes at the smelter<sup>76</sup>. Decarbonisation of the aluminium production chain can, therefore, be carried out in three main ways<sup>77</sup>:

- Improving the energy profile: increasing the share of renewable energy consumption, installing CCS/CCUS, and improving the energy efficiency of technologies.
- Reduce fuel consumption in production through the introduction of CCS/CCUS, inert anodes, refinery, and cast house electrification.
- Increasing the share of recycled aluminium through the development of an aluminium waste collection system at all stages.

 <sup>&</sup>lt;sup>76</sup> International Aluminium Institute, "Aluminium Sector Greenhouse Gas Pathways to 2050," International Aluminium,
 September 2021, https://international-aluminium.org/resource/aluminium-sector-greenhouse-gas-pathways-to-2050-2021/.
 <sup>77</sup> Ibid.

# Aluminium production criteria

Sector	Manufacturing
Activity	Manufacture of aluminium
ISIC code	2420
Description	Manufacture of aluminium through primary alumina (bauxite) process or secondary
	aluminium recycling.
Objective	Climate change mitigation; Resource resilience and circular economy promotion
Green	<ul> <li>Primary aluminium production where the economic activity complies with all of the following criteria is aligned with the taxonomy if all of the following requirements are met: <ul> <li>the GHG emission intensity does not exceed thresholds presented in Table Aluminium decarbonisation pathway (Table 11);</li> <li>the average carbon intensity for the consumed electricity does not exceed parameters established for green electricity production as defined by Thailand Taxonomy;</li> <li>the electricity consumption for the manufacturing process does not exceed 14.86 MWh/t Al.</li> </ul> </li> <li>Secondary aluminium production is automatically eligible</li> </ul>
Amber	<ul> <li>Specific technological measures can be implemented to bring aluminium production emission and energy intensity in line with the requirements of the green category if:</li> <li>They are implemented before the established sunset date (2040);</li> <li>They decrease either emission intensity or electricity consumption intensity of the production process;</li> <li>The facility has a transition plan aligned with the commitments under the Paris Agreement.</li> </ul>
Red	Activities that do not comply with the green or amber category are harmful to the objective of climate change mitigation.
Criteria Reference	EU Manufacture of Aluminium Criteria; Singaporean Taxonomy

Asset Type	CO <sub>2</sub> e emissi	ons intensity (	(tonnes CO <sub>2</sub> e	per tonne of	<b>aluminiu</b> m
	manufacture	d)			
	2025	2030	2035	2040	2050
Production of	1.484	1.185	0.826	0.520	0.311
primary aluminium					
through electrolysis					

### Table 11 Aluminium decarbonisation pathway

## 5. Manufacture of hydrogen<sup>78</sup>

There are numerous end-to-end hydrogen production pathways, however they are tailored to energy sources, conversion technology, and transport method selected. Thus, it is preferable to develop pathway-agnostic carbon emissions benchmarks. Climate Bonds suggests to use the projection of decreasing threshold values performed to ensure that assets and activities are aligned to a transition pathway that contributes to the 1.5°C target. These benchmarks have 2030, 2040 and 2050 targets that get stricter over time to offer guidance to investors and industry on how emissions should reduce in upcoming decades. Hydrogen production carbon intensity benchmarks can be met by different energy sources and technology options, as has been verified using carbon intensity values estimated by MIT Energy Initiative's SESAME platform<sup>79</sup>.

The scope of the activity involves assets and activities associated with the production, conditioning, conversion, transportation, and storage of hydrogen. It covers activities across the hydrogen value chain, except for end-users, which are part of each end-use sector criteria. The stages of hydrogen production that are under the scope of the Taxonomy are defined in the figure below.

<sup>&</sup>lt;sup>78</sup> The approach in this section does not categorize hydrogen as "green," "brown," or "blue," but instead specifies only the greenhouse gas emission intensity. For more information, please refer to the FAQ section under Thailand Taxonomy.
<sup>79</sup> MIT Energy Initiative, "SESAME," Main, April 30, 2024, https://energy.mit.edu/research/sesame/.

Figure 11 Hydrogen production value chain and activities within the scope of the Taxonomy criteria.



If hydrogen is converted to ammonia or other carriers before transportation, that conversion is out of scope and therefore, for these criteria, it is only up to the point before it is converted, which is relevant and should meet the proposed threshold. The conversion, transportation, and storage **are not currently in scope** due to a lack of global guidance, although additional research is going into developing criteria for those parts of the process separately.

The emission boundary within the hydrogen production value chain for the calculation of carbon intensity thresholds is defined on figure below.



Figure 12 Emission boundary for meeting the thresholds of manufacturing hydrogen

Hydrogen is not a primary energy source but an energy carrier whose production requires high amounts of energy. It can be produced from different energy sources, such as fossil fuels, biomass, renewables, nuclear, and via diverse conversion technologies. Nevertheless, most of its production today is based on fossil fuel-based alternatives: steam methane reforming (SMR) of natural gas and coal gasification; these production pathways have high carbon footprints; hence, making hydrogen production less emission intensive is essential to contribute to decarbonisation of the economy.

Traditionally, different processes used in hydrogen production were associated with certain colours, e.g., "green hydrogen" or "grey hydrogen". However, there is no scientifically verifiable separation of hydrogen by colour, so these criteria will use the traditional Thailand Taxonomy method of creating criteria based on limiting the emission intensity per unit of production. Starting limitation of 3 kgCO<sub>2</sub>e/kgH2 sets a limit that effectively cuts off the overwhelming majority of fossil fuels-based hydrogen production that does not use CCS/CCUS.

To meet the green criteria, hydrogen must be produced according to a decreasing decarbonisation pathway over time, and technologies must meet specific criteria.

The amber criteria of the activity include decarbonisation or retrofitting measures that are applicable within the hydrogen production facility and those that are implemented before the established sunset date of 2040. The facility must also have a decarbonisation plan aligned with the commitments under the Paris Agreement.

Sector	Manufacturing
Activity	Manufacture of hydrogen
ISIC code	2011
Description	Manufacture of low-carbon hydrogen
Objective	Climate change mitigation
Green	The facility must comply with all of the following requirements:
	<ul> <li>Hydrogen production must meet specific carbon intensity thresholds (Table 12)<sup>80</sup>;</li> </ul>

#### Manufacture of hydrogen criteria and thresholds

<sup>&</sup>lt;sup>80</sup> To demonstrate compliance with any of the emissions intensity thresholds set in the Table 12, issuers are required to carry out a life cycle assessment within the system boundary defined in the scope of the present criteria in line with recommendations given in Annex.

	• Facilities must meet relevant requirements listed in Table in the Annex
	depending on the feedstock, electricity source and application of
	CCS/CCUS;
	• Facilities that meet the specific intensity thresholds presented in Table
	in the Annex do not have to meet the following requirements
	associated with CCS/CCUS listed in Table in the Annex: minimum
	capture rate from process and energy emission streams should be 90%
	or emissions reduction at the facility level have to be at least of 50%.
	Note: The use of fossil gas as a feedstock by facilities following 2040 is not
	recommended but given substantial uncertainty regarding the availability of
	hydrogen that is aligned with the Thailand Taxonomy (green category), it is not a
	criterion at this stage. This should be re-evaluated in future iterations.
Amber	Specific technological measures can be implemented to decarbonise hydrogen
	production if:
	• They are implemented before the established sunset date (2040);
	• They are included in the list and comply with the criteria stipulated in
	Table in the Annex;
	• A facility has a transition plan aligned with the commitments under the
	Paris Agreement.
Red	Facilities or measures for which:
	• The energy source is oil, coal, or coal derivatives;
	• The feedstock is coal or coal derivatives;
	• The energy source is biomass from primary sources;
	• The use of wood and other dedicated crops is enabled;
	are harmful to the objective of climate change mitigation.
Criteria Reference	Climate Bonds Hydrogen Criteria; Singapore Taxonomy

# Table 12 Hydrogen carbon intensity thresholds

Asset Type	2025	2030	2040	2050
Production of hydrogen	3	1 5	0.6	0
(kgCO <sub>2</sub> e/kgH2)		1.5	0.0	0

# 6.2 Interim activities

### 1. Manufacture of plastics in primary form

The proposed criteria only cover plastics in primary form and not the final products. For the guidance on plastic waste management please refer to the Waste section of the taxonomy.

Sector	Manufacturing
Activity	Manufacture of plastics in primary form
ISIC code	2013
ISIC description	Manufacture of resins, plastics materials and non-vulcanisable thermoplastic
	elastomers, the mixing and blending of resins on a custom basis, as well as the
	manufacture of non-customised synthetic resins.
Objective	Climate change mitigation; Resource resilience and circular economy promotion
Green	The activity must comply with at least one of the following:
	• production of primary plastics from post-consumer recycled (PCR) plastic
	waste using mechanical recycling methods;
	In cases where primary plastic cannot be processed through mechanical
	recycling or is not economically viable, all primary plastic must be
	produced through environmentally sound <sup>81</sup> chemical recycling.
	Additionally, it must have a lower life-cycle greenhouse gas (GHG)
	emission compared to production using fossil-based raw materials.
	• Primary plastic produced partially or entirely from renewable raw
	materials must be certified (or domestic/
	international certification equivalent) by:
	- Roundtable on Sustainable Biomaterials (RSB) or
	- International Sustainability and Carbon Certification (ISCC)
	Additionally, it must have a lower life-cycle GHG emission than
	production using fossil-based raw materials. Life-cycle greenhouse gas

### Manufacture of plastics in primary form criteria and thresholds

https://www.basel.int/portals/4/basel%20convention/docs/text/baselconventiontext-e.pdf

<sup>&</sup>lt;sup>81</sup> "Environmentally sound" manner means taking all practical steps to ensure that wastes are collected, transported, and disposed of (including after-care of disposal sites) in a manner which will protect human health and the environment against the adverse effects which may result from such wastes. Definition is taken from Basel Convention on the control of the transboundary movement of hazardous waste and their disposal

	emissions must be calculated using ISO 14067:2018, ISO 14064-1:2018 or
	comparable.
	The activity must comply with both of the following:
	• The activity does not use food or feed crops from the land that was
	converted from high-carbon stock land after 01.01.2010.
	Wood biomass must come from plantations that comply with "Forestry
	Plantation" criteria of the Thailand Taxonomy
Amber	N/A <sup>82</sup>
Red	• Primary plastic polymer production is harmful to the objective of climate
	change mitigation.
	• Activities that do not comply with the green or amber category are harmful
	to the objective of climate change mitigation.
Criteria Reference	EU Taxonomy Manufacture of Plastics in Primary Form Criteria

# 6.3 Enabling activities

This section includes manufacturing activities that may emit some emissions themselves; however, their significant impact on the decarbonisation of other sectors is substantial that these initial emissions can be neglected. During the transition from the current state of the economy and society to a sustainable society compatible with the objectives of the Paris Agreement and national decarbonisation targets, this type of activity can be most beneficial. In the future, as the economy develops and the products of these sectors become more widespread, it may be necessary to account for the production and initial issuance of these assets. Until then, the prevention of harm from their use will be achieved through adherence to the DNSH principles.

Sector	Manufacturing
Activity	Manufacture of batteries
ISIC code	2720
Description	Manufacturing or recycling of rechargeable batteries, battery packs and
	accumulators for transport, stationary and off-grid energy storage, and other

# 1. Manufacture of batteries

<sup>&</sup>lt;sup>82</sup> The plastic production criteria do not contain an amber category because this type of production cannot be progressively improved by gradually replacing different elements of the production chain. It can only be completely modified according to the type of raw material consumed.

	industrial applications; manufacture of respective components (battery active
	materials, battery cells, casings, and electronic components).
Objective	Climate change mitigation; Resource resilience and circular economy promotion
Green <sup>83</sup>	The activity complies with one of the following criteria:
	• The economic activity manufacturers rechargeable batteries, battery
	packs and accumulators (and their respective components), including
	from secondary raw materials.
	The activity repurposes batteries that have been produced
	Recycling of end-of-life batteries
Amber	N/A
Red	N/A
Criteria Reference	EU Taxonomy Manufacture of Batteries Criteria

# 2. Manufacture of renewable energy technologies

Sector	Manufacturing
Activity	Manufacture of renewable energy technologies
ISIC code	Various codes
Description	Production of technologies, components and parts that are necessary for
	functioning of low-carbon or renewable energy technologies as defined by the
	Energy section of Thailand Taxonomy.
Objective	Climate change mitigation; climate change adaptation; sustainable use and
	protection of marine and water resources; pollution prevention and control
Green	The economic activity manufacturers renewable energy technologies that meet the
Green	The economic activity manufacturers renewable energy technologies that meet the green criteria set out in Thailand Taxonomy (green category)
Green Amber	The economic activity manufacturers renewable energy technologies that meet the green criteria set out in Thailand Taxonomy (green category) N/A
Green Amber Red	The economic activity manufacturers renewable energy technologies that meet the green criteria set out in Thailand Taxonomy (green category) N/A Manufacture of components, machinery and equipment used solely for the
Green Amber Red	The economic activity manufacturers renewable energy technologies that meet the green criteria set out in Thailand Taxonomy (green category) N/A Manufacture of components, machinery and equipment used solely for the extraction, production, or distribution of fossil fuels is harmful to the objective of
Green Amber Red	The economic activity manufacturers renewable energy technologies that meet the green criteria set out in Thailand Taxonomy (green category) N/A Manufacture of components, machinery and equipment used solely for the extraction, production, or distribution of fossil fuels is harmful to the objective of climate change mitigation.

<sup>&</sup>lt;sup>83</sup> The issue of raw material sourcing can't be currently addressed due to the absence of scientific criteria. The Taxonomy should be updated in this regard soon as these criteria are developed. For the time being, possible harm from the improper resource extraction is addressed through the DNSH principles

Sector	Manufacturing
Activity	Manufacture of low-carbon technologies for transport
ISIC code	Various codes
Description	Manufacturing, repair, maintenance, retrofitting, repurposing, and upgrade of low
	carbon transport vehicles, rolling stock and vessels, as well as components that
	help vessels to transition from amber to the green category
Objective	Climate change mitigation
Green	Manufacture of low-carbon transport vehicles and their respective key
	components <sup>84</sup> , fleets and vessels meeting the criteria set out in Thailand Taxonomy
	(Green and amber categories) are eligible.
Amber	N/A
Red	Manufacture of internal combustion engines-based vehicles is harmful to the
	objective of climate change mitigation.
Criteria Reference	EU Taxonomy Manufacture of Low-Carbon Technologies for Transport Criteria

# 3. Manufacture of low-carbon technologies for transport

# 4. Manufacture of energy efficiency equipment for buildings

Sector	Manufacturing
Activity	Manufacture of energy efficiency equipment for buildings
ISIC code	Various codes
Description	Manufacture of energy efficiency equipment for buildings
Objective	Climate change mitigation; Climate change adaptation (depending on whether
	manufactured equipment supports mitigation or adaptation efforts)
Green	The economic activity manufacturers one or more of the following products and
	their key components necessary to support activity "Installation, maintenance
	and repair of special-purpose building equipment" from Thailand Taxonomy,
	including (but not limited to):
	• light sources rated in the highest class of energy efficiency in accordance
	with local market standards <sup>85</sup> ;

<sup>&</sup>lt;sup>84</sup> Components intended solely for use in vehicles that fulfil the criteria of the taxonomy

<sup>&</sup>lt;sup>85</sup> For Thailand hereinafter this benchmark is established as Energy Label No.5 Three Stars rating or Energy Saving Label (whichever is applicable)

	<ul> <li>space heating and domestic hot water systems rated in the highest two populated classes of energy efficiency in accordance with local market standards;</li> <li>cooling and ventilation systems rated in the highest two populated classes of energy efficiency in accordance with local market standards;</li> <li>presence and daylight controls for lighting systems;</li> </ul>
	<ul> <li>heat pumps comptiant with the technical screening criteria set out in the Taxonomy (green category);</li> <li>facade and roofing elements with a solar shading or solar control</li> </ul>
	<ul> <li>function, including those that support the growing of vegetation;</li> <li>energy-efficient building automation and control systems for residential and non-residential buildings;</li> </ul>
	• zoned thermostats and devices for the smart monitoring of the main electricity loads or heat loads for buildings and censoring equipment;
	<ul> <li>products for heat metering and thermostatic controls for individual homes connected to district heating systems, for individual flats connected to central heating systems serving a whole building, and for central heating systems;</li> </ul>
	<ul> <li>district heating exchangers and substations compliant with the district heating/cooling distribution activity set out in the Taxonomy (green category);</li> </ul>
	<ul> <li>products for smart monitoring and regulating of heating systems and censoring equipment.</li> </ul>
Amber	N/A
Red	Manufacture of building equipment that facilitates the utilisation of fossil fuels is
	harmful to the objective of climate change mitigation.
Criteria Reference	EU Taxonomy Manufacture of Energy Efficiency Equipment for Buildings

Sector	Manufacturing
Activity	Manufacture of other low-carbon technologies
ISIC code	Various codes
Description	Manufacture of household goods that fall into the highest class of national energy
	efficiency scheme <sup>86</sup> and manufacture of technologies aimed at substantial GHG
	emission reductions in other sectors of the economy
Objective	Climate change mitigation
Green	The activity manufacturers one of the following:
	<ul> <li>Household goods that meet the highest performance level for a given good according to the Energy Label No.5<sup>87</sup> rating system or Energy Saving Label rating system<sup>88</sup>.</li> <li>Technologies that are aimed at and demonstrate substantial life cycle GHG emission savings<sup>89</sup> compared to the best performing alternative technology/product/solution available on the market (including technologies and equipment needed to make substantial contribution to the objectives of the Thailand Taxonomy).</li> <li>Equipment for waste treatment in line with the Taxonomy criteria for Waste management sector</li> </ul>
Amber	N/A
Red	N/A
Criteria Reference	EU Taxonomy Manufacture of Other Low-Carbon Technology Criteria

#### 5. Manufacture of other low-carbon technologies

<sup>&</sup>lt;sup>86</sup> For Thailand hereinafter this benchmark is established as Energy Label No.5 Three Stars rating or Energy Saving Label (whichever is applicable)

<sup>&</sup>lt;sup>87</sup> Energy Efficiency Standards Promotion Division and Energy and Environment Management Department, Electricity Generating Authority of Thailand, "โครงการฉลากประหยัดไฟฟ้าเบอร์ 5 -," EGAT, n.d., https://labelno5.egat.co.th/home/
<sup>88</sup> กรมพัฒนาพลังงานทดแทน และอนุรักษ์พลังงาน กระทรวงพลังงาน, "ฉลากประสิทธิภาพสูง," n.d.,

http://www.gmwebsite.com/upload/asiapackprint.com/file/D3.pdf.

<sup>&</sup>lt;sup>89</sup> Life-cycle GHG emission savings are calculated using ISO 14067:2018, ISO 14064-1:2018 or similar standards.

# 6.4 CCS/CCUS-related activities

# 1. CCS/CCUS: Point-source capture of $\ensuremath{\mathsf{CO}_2}$

Sector	CCS/CCUS
Activity	Point-source capture of CO <sub>2</sub>
ISIC code	No code
Description	Capture of CO <sub>2</sub> from a point source in an industrial or power generation facility
Objective	Climate change mitigation
Green	The activity complies with all of the following criteria:
	• Point-source capture of $CO_2$ is eligible only as a supplementary activity for
	the activities in the Taxonomy (for example, in the Manufacturing section)
	<ul> <li>Point-source capture of CO<sub>2</sub> is eligible as green if it makes the target</li> </ul>
	activity compatible with the green criteria for a specific activity. The
	applicability of this option to each individual sector can be found in a
	specific activity article (relevant to sections related to the production of
	cement, basic iron and steel, aluminium, hydrogen and basic chemicals).
Amber	The activity complies with all of the following criteria:
	• Point-source capture of $CO_2$ is eligible only as a supplementary activity for
	the activities in Thailand Taxonomy (for example, in the Manufacturing
	section)
	<ul> <li>Point-source capture of CO<sub>2</sub> is eligible as amber if it makes the target</li> </ul>
	activity compatible with the amber criteria for a specific activity.
	Applicability of this option to each individual sector can be found in a
	specific activity article (relevant for sections related to the production of
	cement, basic iron and steel, aluminium, hydrogen, and basic chemicals as
	well as energy generation from fossil gas).
Red	N/A
Criteria Reference	Singaporean Taxonomy

2. Transportation of captured C	$O_2$
---------------------------------	-------

Sector	CCS/CCUS
Activity	Transportation of captured CO <sub>2</sub>
ISIC code	No code
Description	Captured $CO_2$ transportation via pipelines, ships, railroad cisterns or trucks
Objective	Climate change mitigation
Green	The activity complies with <u>all</u> of the following criteria:
	• The $CO_2$ transported from the installation where it is captured to the
	injection point leads to:
	- If transported by sea: $CO_2$ leakages <sup>90</sup> are less than 3% of the
	mass of $\rm CO_2$ transported regardless of the distance and less than
	2% after 2040
	OR
	- If transported via pipeline: CO <sub>2</sub> leakages are less than 0.5% of
	the mass of $CO_2$ transported.
	• The $CO_2$ is delivered to a permanent $CO_2$ storage site that meets the
	criteria for underground geological storage of $\text{CO}_2$ set out in the activity
	«Permanent sequestration of captured CO <sub>2</sub> » article;
	• Appropriate leak detection systems are applied, and a monitoring plan
	is in place, with the report verified by an independent third party;
	• The activity may include the installation of assets that increase
	flexibility and improve the management of an existing network.
Amber	The activity complies with all of the following criteria:
	<ul> <li>Retrofitting of the existing CO<sub>2</sub> transportation systems in order to bring</li> </ul>
	down the leakage rate from the current rate to the rate specified in the
	green category is eligible as amber;
	• The starting leakage rate may not be above 10 % of the mass of $CO_2$
	transported, regardless of the mode of transportation;
	• The $CO_2$ is delivered to a permanent $CO_2$ storage site that meets the
	criteria for underground geological storage of $CO_2$ set out in Section
	«Permanent sequestration of captured CO <sub>2</sub> »;

<sup>&</sup>lt;sup>90</sup> Leakages are defined as fugitive losses due to equipment leaks, accidents, sabotage and exploitation issues.

	• Appropriate leak detection systems are applied, and a monitoring plan
	is in place, with the report verified by an independent third party;
	• The activity may include the installation of assets that increase
	flexibility and improve the management of an existing network.
	• The sunset date for this activity is designated as 2040.
Red	Transportation or retrofitting of transportation systems that do not comply with
	relevant green and amber criteria are harmful to the objective of climate change
	mitigation.
Criteria Reference	EU Taxonomy Transport of CO2 Criteria; Singaporean Taxonomy

# 3. Permanent sequestration of captured $CO_2$

Sector	CCS/CCUS
Activity	Permanent sequestration of captured CO <sub>2</sub>
ISIC code	No code
Description	Permanent storage of captured $CO_2$ in appropriate underground geological
	formations. This activity does not include nature-based sequestration activities.
Objective	Climate change mitigation
Green	Construction or operation of a permanent $CO_2$ storage facility is eligible if the
	facility complies with requirements and recommendations of ISO 27914:2017 (or
	any other comparable national or international standard) for geological storage
	of CO <sub>2</sub>
Amber	N/A
Red	Construction of new facilities that fail to comply with ISO 27914:2017 (or any
	other comparable national or international standard) is harmful to the objective
	of climate change mitigation.
Criteria Reference	EU Taxonomy Underground Permanent Geological Storage of CO2 Criteria;
	Singaporean Taxonomy

# 4. Utilisation of captured CO<sub>2</sub>

Sector	CCS/CCUS
Activity	Utilisation of captured CO <sub>2</sub>
ISIC code	No code
Description	Utilisation of carbon captured by point-source capture or direct air capture of $CO_2$
Objective	Climate change mitigation

Green	Captured $CO_2$ can be used for the manufacture of durable products (e.g.,
	construction materials stored in buildings, polymers or recyclable products that
	will not be incinerated as a final disposal alternative) or for implementing other
	Taxonomy-aligned activities (e.g. mixing it with cement or adding it to chemicals).
Amber	N/A
Red	<ul> <li>Use of CO<sub>2</sub> for products that release the CO<sub>2</sub> immediately when the</li> </ul>
	products are used (such as in urea, carbonated beverages, or fuels) is
	harmful to the objective of climate change mitigation.
	• Use of $CO_2$ for enhanced oil recovery, and the production of other forms
	of fossil energy sources is harmful to the objective of climate change
	mitigation.
Criteria Reference	Activity card is created for Thailand Taxonomy.

# 6.5 Auxiliary transitional activity

1. Introduction of energy efficiency and decarbonisation measures in manufacturing activities not specified in the Thailand Taxonomy

Sector	Manufacturing
Activity	Introduction of energy efficiency and decarbonisation measures in manufacturing
	activities not specified in the Thailand Taxonomy
ISIC code	Various codes
Description	Introduction of energy efficiency or electrification measures and change of energy
	sources in manufacturing activities that lead to substantial reduction of emission
Objective	Climate change mitigation
Green	Activities whose emission intensity figures are on the trajectory developed using the
	latest version of the SBTi methodology for this type of activity are compliant with
	the green category of Thailand Taxonomy.
	This option is only available for activities in the manufacturing sector that do not
	have their own activity card in this Taxonomy.
Amber	Measures to improve energy efficiency within the manufacturing sector (as defined
	by the last version of ISIC system) can be recognised as transitional (amber) under
	Thailand Taxonomy if the activity does not have specific criteria included in the
	taxonomy, and:
	Option 1 (must comply with all three):

	• The applied measures increase energy efficiency (energy input per unit of output) by at least 40% relative to the energy efficiency of facility baseline before the measures were applied. Final reduction of the emission intensity must be achieved no later than the Taxonomy sunset			
	<ul> <li>date for amber activities (2040).</li> <li>If the production facility where the activity takes place uses hydrocarbons in any form (fuel or feedstock), the application of measures shall lead to a reduction in the use of hydrocarbons.</li> <li>The facility has a transition plan that is consistent with the Paris</li> </ul>			
	Agreement commitments <sup>31</sup> . Option 2 (must comply with both):			
	<ul> <li>Measures taken lead to electrification of the main production processes;</li> <li>Measures implemented lead to change the type of electricity consumed by the enterprise from non-renewable to renewable (compliant with the green category of the Thai Taxonomy). Acquisition of PPA certificate does not count for this criterion, the manager of the facility must provide proof of direct connection to a renewable energy source or proof of in situ renewable installation. Any % of replacement of non-renewable electricity with renewable one is considered compliant with this criterion.</li> </ul>			
Red	<ul> <li>Application of energy efficiency measures for the activities associated with:</li> <li>manufacture of equipment for the extraction of oil, gas, and coal;</li> <li>manufacture of equipment for transportation, storage, and processing of any hydrocarbons;</li> <li>manufacture of vehicles, ships, planes with internal combustion engines.</li> <li>manufacture of weapons and weapon systems (ISIC Code 2520)</li> <li>is harmful to the objective of climate change mitigation.</li> </ul>			
Criteria Reference	Designed for Thailand Taxonomy, target is based on Draft Energy Efficiency Plan 2024			

<sup>&</sup>lt;sup>91</sup> Applicable if a credible Paris-aligned reference pathway is developed by a scientific body or an industry organisation. In case if an activity in question does not have such a path developed, this requirement may be ignored

# Annex: Additional information on sustainable hydrogen production

Area	Activity	Mitigation criteria	
General			
Equipment and	Acquisition and installation of	Automatically eligible	
components to	electrolysers and membranes		
produce low-	for electrolysers.		
carbon hydrogen			
Carbon Capture	Installation / acquisition of	• The minimum capture rate from process	
and Storage	infrastructure related to $CO_2$	and combustion emission streams is 90% <sup>92</sup> .	
	capture of emissions from	• A quantitative performance report of the	
	hydrogen production.	CCS/CCUS operations, including the	
		following information:	
		- Intended capture rate capacity,	
		maximum capture rate capacity,	
		intended annual capture of CO <sub>2</sub> ,	
		transport of $CO_2$ , and storage of $CO_2$ .	
		Demonstrated MRV (Monitoring, Reporting	
		and Verification) and mitigation measures for	
		methane leaks on site and upstream.	
		• There is evidence <sup>93</sup> that demonstrates the	
		$\rm CO_2$ will be suitably transported and stored	
		in line with the CCS/CCUS criteria of	
		Thailand Taxonomy.	
Carbon Capture	Infrastructure related to	• The minimum capture rate from process	
and Utilisation	capture, transportation, and	and energy emission streams should be 90%	
	utilisation of CO <sub>2</sub> emissions	or emissions reduction at the facility level	
	from hydrogen production.	have to be at least 50%. <sup>94</sup>	

Table 13 Eligible measures for hydrogen production decarbonisation

<sup>&</sup>lt;sup>92</sup> A minimum capture rate must be demonstrated only for specific investments on CCS/CCUS infrastructure. Entire facilities certification does not need to meet this requirement if the facility meet the total carbon intensity benchmark.

<sup>&</sup>lt;sup>93</sup> Either directly from the facility or through contracts or agreements with a third party.

<sup>&</sup>lt;sup>94</sup> A minimum capture rate must be demonstrated only for specific investments on CCS/CCUS infrastructure. Entire facilities that have CCS/CCUS embedded do need to meet this requirement if the facility meet the carbon intensity benchmark.

Area	Activity	Mitigation criteria
		Issuers must present a quantitative
		performance report of the CCS/CCUS
		operations, including the following
		information <sup>95</sup> :
		- Intended capture rate capacity,
		maximum capture rate capacity, annual
		capture of $CO_2$ , annual transport of
		CO <sub>2</sub> , and annual utilisation of CO <sub>2</sub> .
		• Issuers must demonstrate MRV (Monitoring,
		Reporting and Verification), as well as
		mitigation measures for methane leaks on
		site and upstream <sup>96</sup> .
		• There is evidence <sup>97</sup> that demonstrates the
		$\rm CO_2$ will be suitably transported in line with
		the Taxonomy criteria for CCS/CCUS.
		• $CO_2$ must be used for the manufacture of
		durable products (e.g., construction
		materials stored in buildings, or recyclable
		products that will not be incinerated as a
		final disposal alternative).
		• $CO_2$ should not be used for products that
		release the $\rm CO_2$ immediately when the
		products are used (such as in urea,
		carbonated beverages, or fuels)

<sup>&</sup>lt;sup>95</sup> CCS/CCUS performance report must be verified by an independent third party.

<sup>&</sup>lt;sup>96</sup> Neil Slater, "DNV GL Launches Certification Framework and Recommended Practice for Carbon Capture and Storage (CCS/CCUS)," DNV, January 17, 2018, https://www.dnv.com/news/dnv-gl-launches-certification-framework-and-recommended-practice-for-carbon-capture-and-storage-CCS/CCUS–108096.

Monitoring alternatives include satellite-based or drone-based measurement. Additional guidance can be found in the report Best Practice Guidance for Effective Methane Management in the Oil and Gas Sector. Monitoring, Reporting and Verification (MRV) and Mitigation.

United Nations Economic Commission for Europe, "Best Practice Guidance for Effective Methane Management in the Oil and Gas Sector," ECE ENERGY SERIES (UNITED NATIONS, 2019),

https://unece.org/fileadmin/DAM/energy/images/CMM/CMM\_CE/Best\_Practice\_Guidance\_for\_Effective\_Methane\_Manageme nt\_in\_the\_Oil\_and\_Gas\_Sector\_\_Monitoring\_\_Reporting\_and\_Verification\_\_MRV\_\_and\_Mitigation-\_FINAL\_\_with\_covers\_.pdf. <sup>97</sup> Either directly from the facility or through contracts or agreements with a third party
Area	Activity	Mitigation criteria		
		• CO <sub>2</sub> is not used for enhanced oil recovery,		
		and the production of other forms of fossil		
		energy sources.		
Electrification of	Revamps, modifications and	Automatically eligible		
processes	acquisition of equipment and			
	other infrastructure necessary			
	for the electrification of the			
	processes			
Relating to the feedstock used				
Using biomass as	• Infrastructure to	• The biomass used complies with the criteria		
a feedstock	produce hydrogen using	applicable for biomass sourcing set out in		
	biomass;	the Taxonomy criteria for bioenergy.		
	<ul> <li>Refurbishment and</li> </ul>	• Primary organic streams are only eligible if		
	retrofitting of facilities to	certified as sustainable by Roundtable on		
	use biomass;	Sustainable Biomaterials or International		
	• Acquisition of	Sustainability and Carbon Certification.		
	equipment to produce	<ul> <li>Wood is eligible only if produced on a</li> </ul>		
	hydrogen using biomass;	sustainable plantation as defined by the		
		Thailand Taxonomy's Forestry Criteria		
Using landfill gas	Infrastructure to	Issuers must demonstrate MRV (Monitoring,		
as a feedstock	produce hydrogen using	Reporting and Verification) and mitigation		
	landfill gas;	measures for methane leakages on-site and		
	<ul> <li>Refurbishment and</li> </ul>	upstream <sup>98</sup> .		
	retrofitting of facilities	Landfill gas complies with the Taxonomy criteria		
	using landfill gas as a	for waste management and landfill gas recovery.		
	feedstock;			
	Acquisition of			
	equipment to produce			

<sup>&</sup>lt;sup>98</sup> Monitoring alternatives include satellite-based or drone-based measurement. Additional guidance can be found in the report United Nations Economic Commission for Europe, "Best Practice Guidance for Effective Methane Management in the Oil and Gas Sector," ECE ENERGY SERIES (UNITED NATIONS, 2019),

https://unece.org/fileadmin/DAM/energy/images/CMM/CMM\_CE/Best\_Practice\_Guidance\_for\_Effective\_Methane\_Manageme nt\_in\_the\_Oil\_and\_Gas\_Sector\_Monitoring\_Reporting\_and\_Verification\_MRV\_and\_Mitigation-\_FINAL\_\_with\_covers\_.pdf.

Area	Activity	Mitigation criteria		
	hydrogen using landfill			
	as a feedstock;			
Using manure-	• Infrastructure to	• Issuers must demonstrate MRV (Monitoring,		
biomethane	produce hydrogen using	Reporting and Verification), as well as		
	manure biomethane;	mitigation measures for methane leaks.		
	Refurbishment and	Manure biomethane complies with the		
	retrofitting of facilities	Taxonomy criteria for waste management		
	using manure	criteria for composting.		
	biomethane;			
	<ul> <li>Acquisition of</li> </ul>			
	equipment to produce			
	hydrogen using manure			
	biomethane;			
Relating to the electricity source				
Using wind,	<ul> <li>Infrastructure to</li> </ul>	Renewable energy produced on-site must comply		
solar, hydro, and	produce hydrogen using	with the most up-to-date Taxonomy criteria for		
geothermal	renewable energy	the relevant source of energy.		
energy-based	sources	Issuers must demonstrate the use of only		
electricity	<ul> <li>Refurbishment and</li> </ul>	additional renewable electricity. To do that,		
	retrofitting of facilities	issuers can implement the following options:		
	using renewable energy	<ul> <li>Benewable-based<sup>99</sup> captive power</li> </ul>		
	sources	generation.		
	<ul> <li>Acquisition of</li> </ul>	OR		
	equipment to produce	<ul> <li>A power purchase agreement</li> </ul>		
	electrolytic hydrogen	demonstrating a commercial link of the		
	using renewable energy	electrolyser with new renewable power		
	sources	capacity;		
		OR		
		Excess of renewable-based electricity that		
		would have been otherwise curtailed.		
		Further, the temporal and geographical		
		correlation between the additional renewable		

<sup>&</sup>lt;sup>99</sup> Energy produced from renewable sources such as wind, solar, and small hydropower generation

Area	Activity	Mitigation criteria
		electricity generation and the electrolyser
		electricity consumption must be demonstrated.
		Temporal correlation: Issuers must
		demonstrate that the electricity is
		produced and used simultaneously, on a
		monthly basis, using telemetry
		measurement techniques. Renewable
		electricity that has been locally stored can
		be used as well.
		Geographic correlation: Issuers must
		demonstrate physical capacity to transport
		the electricity from the renewable
		generation plant to the electricity
		consumption site. The electricity must not
		pass a zone of grid congestion.
Using low-carbon	Infrastructure for the	The carbon intensity of the electricity grid must
electricity	production of hydrogen using	ensure that the production process is in
	electricity from the grid.	compliance with the total carbon intensity
		benchmark in Table: Hydrogen carbon intensity
		thresholds.

## Life cycle assessment recommendations

Methodological notes for Life Cycle Assessment (LCA) of hydrogen emissions:

• The life cycle assessment should follow the latest releases of ISO std<sup>100</sup> (ISO 14040, ISO 14044 for life-cycle assessment, and ISO 14067 for product carbon footprint). The Recommendation 2013/179/EU will be acceptable for assets located in the EU. Results should be verified by an independent third party.

<sup>&</sup>lt;sup>100</sup> ISO standards available at: ISO/TC 207/SC 5 [ISO], "ISO 14044:2006 - Environmental Management — Life Cycle Assessment — Requirements and Guidelines," ISO, 2006, https://www.iso.org/standard/38498.html.;

ISO/TC 207/SC 5 [ISO], "ISO 14040:2006 Environmental Management — Life Cycle Assessment — Principles and Framework," ISO, 2006, https://www.iso.org/standard/38498.html.

- GHG emissions must be estimated for a purity of 99.9% vol, and a gauge pressure of at least 3 MPa using correction factors. For pressures higher than 3 MPa, additional energy compression emissions must be included as well.
- The methodology factor in a Global Warming Potential for a period of 100 years (GWP100) for methane should be 28<sup>101</sup>.
- GHG emissions accounting:

## Etotal = E1 + E2 + E3 + E4 + E5 - E6 + E7 + E8

*E total*: Total emissions

*E1:* Upstream feedstock-related emissions (including sourcing<sup>102</sup>, processing, transport, and storage)

*E2:* Upstream energy-related emissions (including sourcing, processing, transport, and storage)

- *E3:* Fugitive emissions (Including hydrogen emissions)
- E4: Process emissions
- *E5:* CCS/CCUS emissions related to energy consumption and leakages
- *E6:* Carbon emissions captured
- E7: Compression and purification emission (Energy required to compress and purify hydrogen)

*E8:* Transportation emissions to the site where hydrogen will be used (energy and electricity-related emissions and fugitive emissions during transportation)<sup>103</sup>

<sup>&</sup>lt;sup>101</sup> Fifth Assessment Report- IPCC

<sup>&</sup>lt;sup>102</sup> Depending on the feedstock, it can be extraction, cultivation, or collection

<sup>&</sup>lt;sup>103</sup> Transportation infrastructure emissions are not included

## Additional guidance for different production pathways up to the point of production<sup>104</sup>

The International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE) methodology working paper contains guidelines for a calculation method for GHG accounting for the following production pathways up to the point of production<sup>105</sup>:

- Steam Methane Reforming combined with CCS/CCUS: Appendix P1 of IPHE working document
- Biomass as a feedstock combined with CCS/CCUS: Appendix P5 of IPHE working document
- Manure-based production: **P5.4** Bio-digestion
- Landfill gas-based production: **P5.4** Bio-digestion
- Biomass from secondary sources: **P.5.5** Biomass gasification.
- The IPHE working document also has guidelines for emission sources and allocation for biomass-based production:
- Emissions sources in Biomass-Based Hydrogen Routes/CCS/CCUS: Appendix P.5.6
- Allocation for the Biomass/CCS/CCUS pathway: Appendix P.5.7

<sup>&</sup>lt;sup>104</sup> The IPHE methodology will develop guidelines for transport emissions accounting in the coming months.

<sup>&</sup>lt;sup>105</sup> IPHE, "Methodology for Determining the Greenhouse Gas Emissions Associated With the Production of Hydrogen" (IPHE Hydrogen Production Analysis Task Force, November 2022),

https://www.iphe.net/\_files/ugd/45185a\_6159cefcd88f4d9283ab0e60f4802cb4.pdf.